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ABSTRACT

This document is a textbook of emergency medical procedures to be used for training emergency medical technicians. The book is organized into 15 modules, each containing 1 to 10 units. Each module contains information illustrated with line drawings, a glossary, and references. The modules cover the following topics: the role of the emergency medical technician, issues, and legal considerations; human systems and patient assessment; shock and fluid therapy; general pharmacology; the respiratory system; the cardiovascular system; the central nervous system; soft-tissue injuries; the musculoskeletal system; medical emergencies; obstetric and gynecologic emergencies; pediatrics; management of emotional crisis; extrication and rescue techniques; and telemetry and communications. A glossary for the whole volume, references, and a list of contributors complete the book. (KC)

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# Emergency Medical Care

## A Manual for the Paramedic in the Field

CE038663

# The EMT Oath*

*Be it pledged as an Emergency Medical Technician, I will honor the physical and judicial laws of God and man. I will follow that regimen which, according to my ability and judgment, I consider for the benefit of my patients and abstain from whatever is deleterious and mischievous, nor shall I suggest any such counsel. Into whatever homes I enter, I will go into them for the benefit of only the sick and injured, never revealing what I see or hear in the lives of men.*

*I shall also share my medical knowledge with those who may benefit from what I have learned. I will serve unselfishly and continuously in order to help make a better world for all mankind.*

*While I continue to keep this oath unviolated, may it be granted to me to enjoy life, and the practice of the art, respected by all men, in all times. Should I trespass or violate this oath, may the reverse be my lot. So help me God.*

Charles Gillespie, M.D.

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*The NHTSA extends its gratitude for permission to reprint this oath as a guide for all EMT's who are serving today and for those who will serve in the future.

U.S. Department
of Transportation

**National Highway
Traffic Safety
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# Emergency Medical Care

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This textbook is intended solely as a guide to the appropriate procedures to be employed when rendering emergency care to or transporting the sick or injured. It is not intended as a statement of the standards of care required in any particular situation, since circumstances and patients' physical condition can vary widely from one emergency to another. Nor is it intended that this text book shall in any way advise emergency personnel concerning legal authority to perform the activities or procedures discussed. Such local determinations should be made only with the aid of legal counsel.

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# Foreword

Each year many thousands of people needlessly die in the United States, because of the lack of adequate and available emergency medical services. Most of the deaths occur from coronary disease, accident injury, burns, poisoning, alcohol and drug overdose, immature infancy, and acute psychiatric disorders. The Federal Emergency Medical Services (EMS) program is directed toward saving these lives and assisting the millions of other people that are in potential death and disability situations.

A major need of the prehospital portion in the EMS systems program has been to develop a national standard for training personnel in advance life-support techniques and to define the standard skills required of the Emergency Medical Technician (EMT)-Paramedic. The National Highway Traffic Safety Administration, Department of Transportation, has taken the lead to develop the standards of the EMT-Paramedic training course. The curriculum is comprehensive and consists of three components: didactic, clinical (inhospital), and field internship. The course is available in modules to permit presentation appropriate to local needs and resources. But most of all, the course sets forth specific skills, comprehensive knowledge, and performance competence that are necessary for a national standard of instruction.

It is the mission of the Interagency Committee on Emergency Medical Services to provide national coordination of the Federal EMS program and to insure communication between the major agencies and departments involved in emergency medical services. The EMT-Paramedic course has been reviewed and approved by the Interagency Committee on Emergency Medical Services. The course is eligible for Federal funding through appropriate grant application mechanisms. The Department of Transportation, the Department of Health, Education, and Welfare, and the Department of Labor have specifically endorsed this training course for funding.

The National Highway Traffic Safety Administration, Department of Transportation, is to be complimented on the completion of this excellent curriculum that will assist in the improvement of standards and quality of emergency medical care to all citizens.

Louis M. Hellman, M.D.
Chairman, Interagency Committee
on Emergency Medical Services

# Preface

There are several thousand paramedics in the United States who are working out of large urban centers and rural volunteer rescue squads, performing skills ranging from simple bandaging to transthoracic cardiac pacing, and annually rendering care to hundreds of thousands of sick and injured. The paramedic, like the Emergency Medical Technician—Ambulance (EMT-A), was once an isolated phenomenon of a few major emergency medical systems, but now is a recognized allied health professional who is here to stay. However, with recognition of the paramedic's professional status has come concern for the development of performance standards based on standards of training.

Although the National Highway Traffic Safety Administration (NHTSA) has been involved in preparing training materials for emergency medical technicians at various levels, the development of this text posed the difficult problem of determining just how much information a paramedic should know to function professionally in emergency care. On the one hand, the paramedic should not function as an automation, who performs by rote at a physician's command. On the other hand, the paramedic should not be expected to be as educated as a physician. What then should a paramedic know?

There is no simple list of facts, no well-defined set of information concerning the training of paramedics; nor is such a list likely to be written. Different physicians charged with training paramedics will, and should, differ in their ideas of what ought to be taught. In selecting the contents of this text, NHTSA was guided to two general principles:

> d The course should provide enough information to enable a paramedic to carry on life support in the field, even if telecommunication with a physician is interrupted. Thus, the paramedic should have enough knowledge of pathophysiology to make a basic diagnosis and apply appropriate therapy in a variety of circumstances.
>
> d The knowledge objectives should be geared to the special constraints of care in the field and unnecessary distinctions should not be made. The nuances of diagnosing different kinds of abdominal pains, for example, merit less emphasis than the differentiation of cardiac asthma from asthma, since in the former case the treatment in the field will not be greatly affected by making an accurate diagnosis, while in the latter case accurate diagnosis is crucial in the choice of therapy. Thus, priority has been given to areas where it was felt the paramedic's knowledge would make a difference in the field.

Many of the techniques taught in this course require a physician's order, whether in person, by telecommunications, or through standing orders. The technique is described in detail so the paramedic may become familiar with the actions that might be expected in various circumstances. However, local customs and regulations will determine the mechanisms by which procedures are authorized, if at all, in any given system. For example, while the technique of endotracheal intubation is described, it is not anticiapted that the paramedic will ordinarily carry out this procedure without the guidance of a physicians. The paramedic should, however, be familiar with the technique and be prepared to perform it if authorized to do so by a medical director.

The principles of extrication/rescue are not emphasized in this course because, strictly speaking, they are not part of a paramedic's job as a health professional. It is assumed, however, that students taking this course have been certified by the State EMS agency and have, therefore, learned the fundamentals of extrication/rescue from the prerequisite NHTSA *Crash Victim Extrication Course.* If, however, a student paramedic has not learned the fundamentals of extrication/rescue, they should be included in this course (Module XIV: Rescue Techniques). In this latter case, the NHTSA *Crash Victim Extrication Course* or an approved equivalent should be given as a minimum.

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## Module I.
# Emergency Medical Technician-Paramedic

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# MODULE I

# Emergency Medical Technician-Paramedic

## Unit 1. The Role and Responsibilities of the Emergency Medical Technician-Paramedic

### The Health Care Professional

To understand how important the paramedic is to the emergency medical services (EMS) team, you should first understand the basic term, "health care professional." The dictionary defines health as the state of being sound of body, mind, or soul, and especially of being free from physical disease or pain. Care is defined as painstaking or watchful attention; caring or liking; management; or solicitude—"concern for one in pain, illness, or distress." A professional is a person who has certain special skills and knowledge and who conforms to professional standards of conduct and performance.

So an Emergency Medical Technician-Paramedic (EMT-P) is a health care professional—a person who has special skills and knowledge in emergency medicine, who is concerned about other people's health and well-being, and who caringly attends to the tasks of promoting that health and well-being.

To further understand the EMT-P's role and responsibilities, you must remember that advanced life support training and skills are *extensions* of the Emergency Medical Technician-Ambulance (EMT-A) training. The EMT-A is also an appropriately identified health care professional. Most patient care situations require basic life support skills. The EMT-P must not only be proficient in *advanced* life support procedures, but also remain highly competent in *basic* life support techniques.

In order that the initial response to a medical emergency be prompt and efficient, the emergency vehicle must always be adequately supplied and maintained. Care of the ambulance is one of a paramedic's most basic responsibilities, as is driving safely and within the local traffic laws. The EMT-P must also be sure that the ambulance's equipment is always in place and in sound working condition.

At the scene of the medical emergency, the paramedic directs bystanders and first responders (police and firefighters providing medical assistance); your first concern is care and safety of the patient. Respect for the patient's dignity calls for you to shield the patient from curious onlookers. In addition, every EMT-P must stay calm under stress and deal courteously and professionally with people whose behavior has been altered by illness or anxiety—both the victims and the bystanders.

The paramedic's responsibilities extend beyond the basic stabilization of the patient before and during transportation, though. Paramedics are trained to perform such complex diagnostic and medical procedures as intravenous cannulation, endotracheal intubation, recognition of cardiac arrhythmias, and administration of drugs.

This means that not only must paramedics be competent at all times, they must also function under an organized plan of medical control for the EMS system within which they operate. Once the patient is in a paramedic's care, it is of extreme importance that the doctors whom the EMT-P will be talking to should have an accurate, understandable report of the patient's history, physical findings, and treatment. You must also make sure that a complete written record of the patient's care is made available to the admitting hospital and becomes part of the ambulance service's official records.

Although most paramedics now serve in the field, an increasing number are beginning to hold positions within the emergency department. Some EMT-P's are training other emergency medical technicians, including those in administrative positions, for work as managers and supervisors in the ambulance or EMS system. Some EMT-P's have become public educators—for example, some are certified instructors for the American Heart Association. As public educators, EMT-P's can help people learn how to call for emergency services efficiently and what to do in a medical emergency when a police officer, firefighter, or paramedic is not present. In addition, citizens can be trained in such first aid techniques as cardiopulmonary resuscitation (CPR)—thus becoming "extenders" for paramedics just as paramedics are extenders for doctors.

Whatever the job, a paramedic's professional responsibilities will include maintaining a working understanding of the different components of the EMS system; maintaining a professional level of ethics, technical skills, and appearance; and working cooperatively with other members of the EMS team (first responders, EMT-A's, nurses, and physicians). As a health care professional, the EMT-P is a vital member of the team. As such, you must understand the EMS system in which you work as well as your responsibility to the public before, during, and after a medical emergency.

## Job Description[1]

### WORK REQUIREMENTS

Responds to emergency calls to provide efficient and immediate care to the critically ill and injured; transports the patient to a medical facility.

After receiving the call from the dispatcher, drives ambulance to the address or location given, using the most expeditious route as dictated by traffic and weather conditions. Observes traffic ordinances and regulations concerning emergency vehicle operation.

Upon arrival at the scene of an accident or illness, parks the ambulance in a safe location. In the absence of police, enlists bystanders' help to create a safe traffic environment. This would include placing road flares, removing debris, and redirecting traffic to protect both the injured and the EMT's.

Determines the nature and extent of illness or injury. If there is more than one injury or patient, establishes which should be treated first. Renders emergency care, for example opening and maintaining an airway; giving positive pressure ventilation; giving cardiac resuscitation; controlling bleeding; treating shock; immobilizing fractures; bandaging; assisting in childbirth; managing mentally disturbed patients; and providing initial care of poison and burn patients. Administers drugs, including intravenous fluids, as directed by a physician.

Reassures patients and bystanders by working confidently and efficiently. Avoids mishandling and carelessness while working as quickly as is safe. Looks for medical identification emblem as a clue in providing emergency care.

Where patients must be gotten out of entrapment, assesses the extent of injury; gives all possible emergency care and protection to the trapped patient; and uses the prescribed techniques and appliances for removing the patient safely. Radios the dispatcher for additional help or special rescue or utility services if they are needed. Provides light rescue service if the ambulance does not have the right equipment and the specialized unit is on the way. After the patients are freed, provides additional care in sorting of the injured in accordance with standard emergency procedures.

Complies with regulations on the handling of the deceased, notifies authorities, and arranges for protection of property and evidence at the scene.

Assists in lifting the stretcher, placing it in the ambulance, and seeing that the patient and stretcher are secured and that emergency care is continued if necessary.

After determining the condition of the patient and the extent of the injuries, and knowing the relative locations and staffing of emergency hospital facilities, decides which facility will be most appropriate for treatment (for example, a children's hospital, a poison center) unless otherwise directed by the dispatcher or a physician. To assure prompt medical care on delivery, reports directly to the emergency department or control center the nature and extent of injuries, the number of patients being transported, and the destination. For serious cases, may ask for additional advice from the hospital physician or emergency department.

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[1] This job description applies to the EMT-A, the EMT-AA, and the EMT-P, although originally it was meant only for the EMT-A. The only differences lie in each category's competency level as distinguished by the level of training.

Constantly observes patient enroute to emergency facility. Administers additional care as indicated or directed by physician.

Identifies diagnostic signs that may require radio communications with a medical facility for care enroute and that may require that special professional services and assistance be available immediately on arrival at the medical facility.

Assists in lifting and carrying the patient out of the ambulance and into the emergency department.

Reports verbally and in writing what injuries were identified and what patient care was administered both at the emergency scene and in transit. This report is made to the emergency department staff for diagnostic purposes and for the record; a copy is filed with the EMS's official records. Upon request, assists the emergency department staff.

After each trip, replaces used linens, blankets, and other supplies; sends supplies for sterilization; and checks all equipment carefully so that the ambulance is ready for the next run. Maintains ambulance in efficient operating condition. Ensures that the ambulance is kept clean and tidy. In accordance with local or State regulations, decontaminates the vehicle's interior after it has transported a victim who had a contagious infection or was exposed to radiation. Determines that the vehicle is in proper operating condition by checking gas, oil, the water in both the battery and the radiator, and tire pressure. Maintains familiarity with special equipment used by the ambulance service.

> **NOTE:** Seniority and responsibility should be determined by the EMS supervisor. Attendants and drivers should be equally trained so that they may function interchangeably or independently in caring for multiple casualties.

## Education, Training, and Experience

A high school education or its equivalent is considered minimal. Must be 18 years of age or older.

The minimum training shall be that prescribed in the basic training program for emergency medical technicians-ambulance (EMT–A's) of the U.S. Department of Transportation.

Has practical experience in the care and use of the emergency equipment commonly accepted and employed, such as suction machines, oxygen delivery systems (installed and portable), spineboards, fracture kits, emergency medical care kits, obstetrical kits, intravenous kits, stretchers of various types, and light rescue tools, as well as basic automobile mechanics. Understands sanitizing and disinfecting procedures. Knows safety and security measures.

Acquires, through critiques and conferences with emergency department personnel, constructive criticism of care rendered and instruction about advances in patient care and new or improved equipment.

Acquires a thorough knowledge of the territory within his or her service area and of the traffic ordinances and laws concerning the emergency care and transportation of the sick and injured. Has necessary driver and professional licenses as required by law.

## Special Characteristics

### APTITUDES

Motor coordination in administering emergency care of the critically ill and injured, in lifting and carrying patients, and in driving the ambulance.

Manual dexterity and physical coordination. Must perform carrying, lifting, extricating, climbing, hoisting, and similar maneuvers in a manner not detrimental to the patient, fellow workers, or self.

Facility to give and receive verbal and written directions and instruction.

### INTERESTS AND TEMPERAMENT

- A pleasant personality.
- Leadership ability; firm, yet courteous.
- Good judgment under stress.
- Clean and neat in appearance.
- Good moral character.
- Emotional stability and psychological adaptability.

### PHYSICAL DEMANDS

Normal good health.

Ability to lift and carry up to 100 pounds.

Color vision (necessary for examining patients as well as to distinguish traffic signs and lights).

Good eyesight (necessary for driving and for examining the patient—correction by lenses permitted).

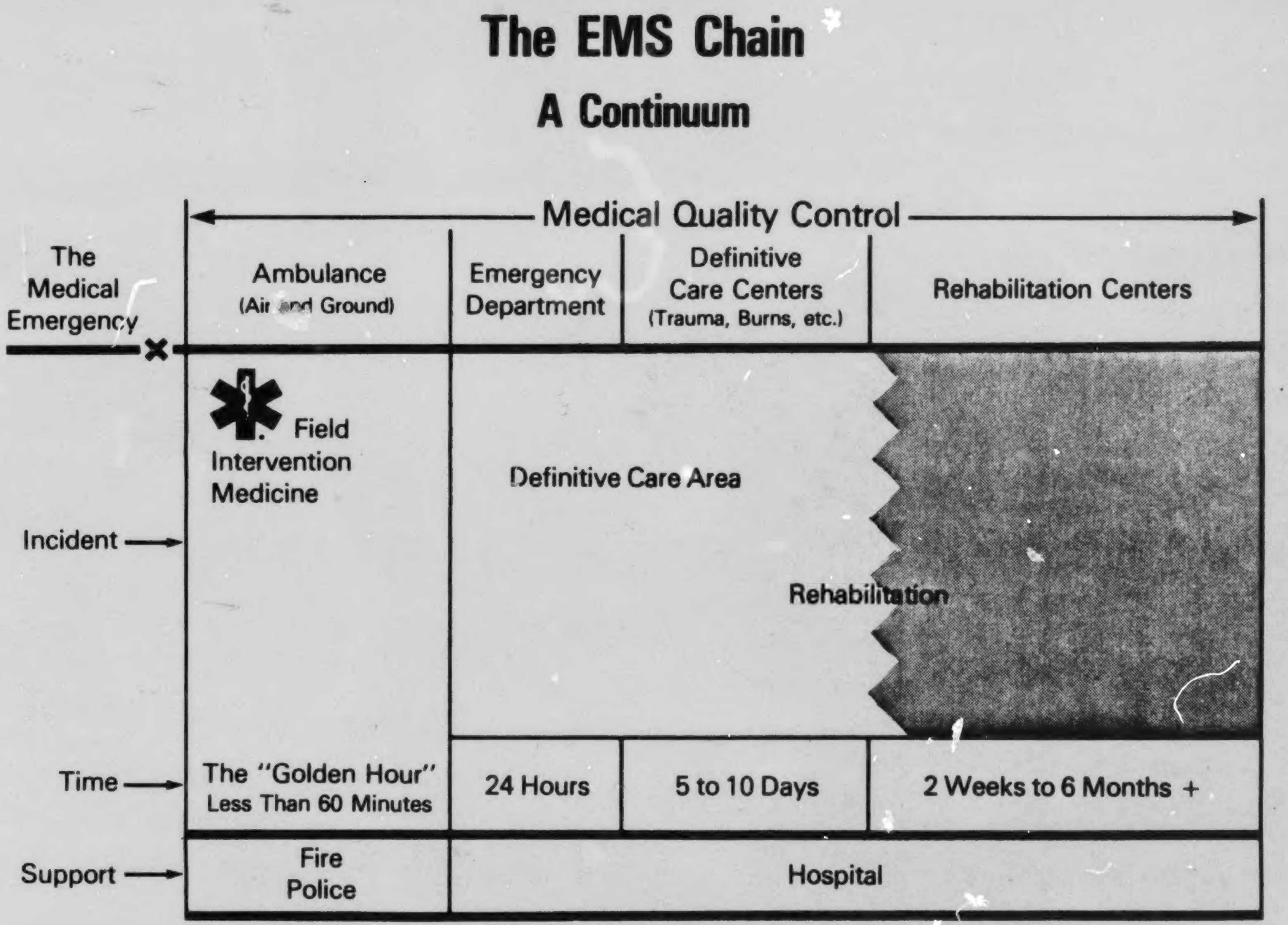
# Unit 2. The Emergency Medical Services System

## The EMS Chain—A Continuum

Emergency medical care should be thought of as a continuum—not a thing in itself, but a process, a chain of services to take the injured or sick back to health. (Figure I–1) The EMS system has six links in its part of the chain: communications, transportation, training, definitive care, public education, and recordkeeping and evaluation.

- **Communications** includes citizen-to-EMS, dispatcher-to-EMS team, and paramedic-to-doctor communications.
- *Transportation* has two important meanings: It means getting the appropriately trained individuals and the right equipment to the scene of a medical emergency; and it means getting the emergency patient to the medical facility that can

Figure 1. The EMS Chain-A Continuum


The EMS Chain
A Continuum
Medical Quality Control
The Medical Emergency
Ambulance (Air and Ground)
Emergency Department
Definitive Care Centers (Trauma, Burns, etc.)
Rehabilitation Centers
Field Intervention Medicine
Definitive Care Area
Rehabilitation
Incident
Time
The "Golden Hour" Less Than 60 Minutes
24 Hours
5 to 10 Days
2 Weeks to 6 Months +
Support
Fire
Police
Hospital

NHTSA Emergency Medical Services Division, and
Maryland Institute for Emergency Medical Services Systems

give the patient the best care. This is called "field intervention medicine."

- *Training* covers all aspects of professional training and education for members of the EMS team.
- *Definitive Care* is a special term used in this manual to refer to the medical facility that will handle the patient out of the field—for example, hospitals, poison centers, cardiac care units, etc. For the paramedic in the field, definitive care means working (usually by radio) with the physician; medical care rules and customs; categorization of emergency medical facilities; and knowing the appropriate procedures for transferring patients from one institution to another.
- *Public education,* including public information, involves letting the public know how the EMS system works, how to work with the EMS system efficiently, and what sorts of first aid would be appropriate to apply before the EMT arrives.
- *Recordkeeping and evaluation* help determine how efficient the EMS system is and how it can be improved. They are also important in the event that an EMT becomes a witness or defendant in a court suit.

## *Communications*

**CITIZEN-TO-EMS.** Often a person's ability to recognize a serious medical emergency and knowledge of how to get help mean the difference between life and death. The problem is that recognition can be delayed because neither victim nor bystanders know the basic symptoms. (The heart attack victim, for example, may wait as long as 3 hours after the onset of symptoms before seeking help.) Moreover, most people do not know first aid—or even if they do, they can lose their heads in an emergency.

Even after the symptoms of a medical emergency are recognized, many people don't know the right telephone number to call for an ambulance. Some parts of the country have still not adopted the 911 telephone number, so that many calls for emergency medical help are delayed because they've been made to inappropriate private and public service agencies.

These problems can both be countered through an effective EMS public education and information program.

Once the victim or bystander recognizes the medical emergency, the typical ways of calling for help are by dialing 911 or a similar emergency telephone number; by calling the telephone operator; by using a highway emergency callbox; or by using the citizens band (CB) radio.

**DISPATCHER-TO-EMS TEAM.** The EMT-A and the EMT-P are not the only members of the EMS team. Other first responders, such as police and firefighters, have important roles as well. The police handle traffic, control crowds, and complete vehicle accident reports (required by most State laws). Firefighters not only protect the scene from possible fire or explosion; they also help remove victims that have been entrapped once it is safe to do so.

Considering which first responder is closest to the medical emergency is also important at this stage of the EMS response. Often police and fire units can reach the site before the ambulance does; having trained first responders at the scene, whether EMT's, police, or firefighters, can make the difference between life and death.

A community that is striving for the best initial response to a medical emergency should design its system so that a first responder is on the scene within 5 minutes of the call for help. In urban areas, effective emergency services probably already exist. In rural areas, where distance is a factor, radio pagers may help achieve the 5-minute goal.

An EMS communication coordination center (CCC) can coordinate all area ambulance and medical radio frequencies. The CCC can also "patch" (connect telephone and radio capabilities) police, fire, and ambulance services, so that any one of them can communicate directly with any other (see Module XV). It is the CCC's responsibility also to coordinate the use of the recently designated ultrahigh-frequency radio channels allocated by the Federal Communications Commission for transmitting medical voice and telemetry signals.

**PARAMEDIC-TO-DOCTOR.** From a patient care standpoint, the ability of the paramedic to communicate directly with a doctor is the most important aspect of EMS communications. It allows continuous medical direction at the scene, since the physician can communicate from the emergency department, home, or even a far-off city through a phone patch into the radio network. In sparsely populated areas, satellite communications may even be used.

The person at the scene who has the most medical training (usually the EMT-P) must evaluate the total picture, assessing the sickness or injury and its seriousness. In cases where there is more than one injury or more than one patient, the paramedic must decide which patients need advanced life support, which do not, and in what order treatment should take place. This decisionmaking process is called triage, from a French word meaning "to sift." Patients who need only basic life support should be left in the hands of the first responders or EMT-A's, while the paramedic concentrates on those who need advanced life support. No matter what the situation, you must remember not to add confusion to the scene. A paramedic must take medical control firmly, confidently, and efficiently.

In contacting the physician, make sure that your report is as complete, accurate, and understandable as possible. Include in your report your assessment of the situation and what steps you have taken, if any. Keep the physician up to date on any significant changes in the patient's condition. Remember, the services the physicians can render will only be as good as their knowledge of the true conditions.

## Transportation

**PARAMEDIC-TO-PATIENT.** Years ago, prehospital care was almost non-existent; the ambulance was mainly a taxi service. Times have changed. The most important thing about EMS is not that it is a system for delivering a patient to a medical facility, but that it can take medically trained personnel and their equipment to the patient. Some of the factors that must be considered include: the best location of ambulances and EMT's so as to minimize the time it takes to get to a patient; the types of equipment and vehicles required; and prearranged modes of patient transportation to the medical facility.

Ideally, the vehicle used to transport the equipment and EMT's to the scene—the ambulance—will be the same vehicle used to transport the patient to definitive care. However, some EMS systems may use other vehicles to transport personnel and equipment to the scene, reserving the ambulance for transporting the patient to definitive care. In such cases, arrangements should be made with an ambulance service so that an ambulance is dispatched to emergency calls at the same time the EMS team is. It must be assumed that at no time is a patient to be passed from the more capable to less capable personnel during the transit phase of care.

No matter what system of transportation is used, the medical equipment in the vehicle should meet the minimum standards outlined in the "Essential Equipment for Ambulances" list provided by the Committee on Trauma of the American College of Surgeons (*Bulletin of the American College of Surgeons*, 1977). The ambulance should also meet Federal specifications as outlined in document KKK–A–1822 or – 1822A (available from the General Services Administration, Washington, D.C.). Additional equipment is needed for advanced care ambulances, usually including a portable monitor and defibrillator, intravenous lines, intubation equipment, and the appropriate drugs and fluid solutions. Advanced care ambulances should also carry at least one EMT-A and one EMT-P.

**PATIENT-TO-FACILITY.** The old rule of thumb, that the best medical facility is the closest, is no longer accepted. Working with the medical direction physician, the paramedic must evaluate the patient's condition and, knowing the capabilities of the medical facilities in the area, decide which one is best staffed and equipped to handle the case. For example, medical authorities recommend that patients with third-degree burns over 30 percent of their bodies be treated at a burn center. The EMT-P's evaluative and advanced life support skills make it possible to take the patient directly to the burn center, rather than first to a hospital and second to a burn center.

Occasionally there may be a problem with distances between medical facilities or lack of a clear understanding between paramedic and doctor about standard operating procedures. One of the main objectives of the well-run EMS system should be to eliminate such problems.

## Definitive Care

The paramedic's role in definitive care requires knowing which medical facilities have which specific strengths. The assessing of hospital emergency services is called *hospital categorization*, and is done by those responsible for planning and coordinating the EMS system. The criteria of hospital categorization include:

- The given area (metropolitan, interstate, or statewide);
- What physicians the facility has on staff and their availability;
- Medical specialties of staff physicians;
- Medical specialties of staff nurses;
- Availability of life support equipment and supplies;
- 24-hour physician coverage in the emergency department;
- 24-hour coverage of laboratory and X-ray facilities;
- Availability and adequacy of special-care facilities (e.g., intensive care unit, cardiac care unit, trauma unit, poison center, burn center, spinal cord injury center); and
- Such other factors as inservice education programs and transfer agreements with other institutions.

Hospitals are no longer categorized in merely general terms—comprehensive, routine, standby, etc. A small rural hospital may not have the total care capability of a large urban medical center, but it may have just the right physician availabilities and special-care capabilities for the particular emergency on hand. It is up to the paramedic to know how the EMS director has categorized the medical facilities in the area and to be able to decide which one is most appropriate.

## Public Education

Helping the general public understand the EMS system and how people can work with it most effectively is not a heavily emphasized part of the EMS continuum, but it is an important one.

The universal number 911, for example, allows the public easy access to the EMS system. By just dialing 911, people in many areas of the country can call for fire fighters, police, or ambulances. If this universal number were adopted nationwide, it would allow emergency services to make an even more effective and coordinated response to medical emergencies.

Public information and education goes beyond this, however. For example, a person who dials 911 is asked for his or her name, address, and telephone number. A person who may be feeling ill or anxious might well ask, "Why are you delaying things asking for my phone number? Get over here!" An effective public information campaign can help people understand the reasons for procedures that may on the face of them seem unnecessarily bureaucratic or time-consuming. (For a further discussion of this, see Module XV, "Telemetry and Communications.")

Getting in touch with the EMS system is the *second* step, however. The first step is recognizing that a medical emergency exists. Citizens should be trained to recognize the symptoms of heart attack, allergic reaction, poisoning, and other not-so-obvious ailments. Citizens can also be trained in first aid techniques, such as CPR, the Heimlich maneuver, stopping bleeding, or coping with someone in shock, so that in the event that neither a first responder nor an EMT is present, the bystander may begin to cope with the emergency.

### Recordkeeping and Evaluation

**RECORDKEEPING.** Even the most skilled and conscientious health care professional may eventually have to go to court, as a witness or even as a defendant in a civil or criminal action. In these circumstances, the best protection is a thorough and accurate medical record. *This point cannot be overemphasized.* Whenever you care for a patient in the field, you should make a careful, detailed record of:

- The date and time the call was received, the times of your arrival and departure from the scene, and the time the patient arrived at a medical facility.
- The information you obtained from the patient or from bystanders (patient history).
- Your observations at the scene.
- The findings of the physical examination.
- Any treatment rendered. (Here, you must be completely precise. Do not write, "IV therapy given." Write, "An IV was initiated under the orders of Dr. X. The I V used a 14-gauge Angiocath and D5W to a keep-open rate....")
- Any changes in the patient's condition while under your care.

Again, you should be as precise and detailed as possible. A medical record may become a legal document that reflects upon its author. A sloppy, incomplete record suggests to the reader (and to the court) that the care of the patient may also have been sloppy and incomplete. Also, a medical record is never the place for flippant or derogatory remarks, about a patient or anything else. At the very least, such remarks could cause you considerable embarrassment if they are later made public.

No EMS system should be considered complete without a well-maintained system of complete and accurate medical records.

**EVALUATION.** The possibility of having one's professional conduct challenged is only one reason for keeping written records of a patient's prehospital care. More important is the fact that detailed, accurate records may be used to evaluate the EMS system, to identify patterns and trends, and to establish means for making the system even more effective.

Information such as the time a call is received, the distances traveled, and the time the ambulance arrives on the scene, properly correlated with geographical and definitive care considerations, can help determine the most appropriate locations for ambulances and other equipment. The written record also provides information that the physician will need in diagnosing the patient and completing his or her medical history. Many States require written records by law when advanced life support procedures are used. Such information can protect the rights of the patients as well as the rights of the EMT-P if any legal questions arise.

### The EMS Continuum

The preceding overview of the EMS system was intended to show you how each of its six facets—communications, transportation, training, definitive care, public education, and recordkeeping and evaluation—interacts with each of the others to provide an uninterrupted flow, or continuum, of the best possible patient care. What emergency medical care is provided in the field has repercussions throughout a patient's return to health, and what you, the paramedic, do has repercussions throughout the EMS system. It is important to remember two things: First, EMS is a *systems* approach to the delivery of lifesaving care; second, *team effort* is the key to achieving the ultimate goal—effective care of the emergency patient.

## Unit 3. National EMS Issues, Goals, and Objectives

### The National EMS Goal

The goal is a simple one—that there be a national, cohesive program of emergency medical service that focuses on the coordinated application of all appropriate resources to turn victims into patients as quickly as possible and to deliver them safely and efficiently to definitive care.

### Field Intervention Medicine—The "Third Service"

Once, ambulances were little more than taxis, and only two first-response services were recognized:

police and fire fighters. Today there is a "third" service—trained, competent people who in caring for victims convert them to patients, who provide life-saving and life-sustaining care both at the scene of an emergency and on the way to definitive care. For the first time in our Nation's history, the general public has access to field intervention medicine.

Field intervention medicine is an armamentarium of designed communications, transportation, training, public education, administration, and ongoing evaluation derived from the military's experience in the development and application of medicine in the field. Drawing on this experience, the DOT program was from the first designed to be field intervention medicine.

In developing its program, the Department of Transportation drew on a vast knowledge bank of research, development, and experience that came from not only the military, but also definitive care institutions and dedicated professionals. It was not necessary to conduct extensive research projects or to demonstrate proven procedures; rather, the task was to bring this knowledge bank to bear on the problem—what the National Academy of Science and Medical Professions call "Accidental Death—The Neglected Disease of Modern Society."

The goal of the DOT program was to package all this available knowledge for use in the civilian sector—to implement effective technical intervention in medical emergencies so as to convert victims to patients as quickly as possible. The contributors and resources in this effort, which took place in the late 1960's and early 1970's, included among others the National Academy of Sciences, the American Academy of Orthopaedic Surgeons, the American College of Surgeons, the American Medical Association, the National Ambulance Association, the American Hospital Association, the American Society of Anesthesiologists, the American Heart Association, the American College of Cardiologists, the American Public Health Association, and many manufacturers of medical equipment.

The issue relating to the third service is not, Does it exist? or Should it exist? The issue is rather how we can ensure that this service gains a national identity, uniformity, and recognition on a par with fire and police services. How can we ensure the appropriate status and stature for those dedicated people who bring this vital medical service to their fellows? How can we ensure that our public EMS service seeks the highest standards of excellence?

**OBJECTIVE:**

To ensure proper recognition of the identity, status, and stature of the emergency medical care practitioner, by all concerned, as a distinct and valued public servant whether employed by the fire service, private purveyer or other service provider.

**MEANS:**

Focus on the solutions to an EMS team member's problems, whether first responder or EMT. The issues include personal recognition, career opportunities, uniform standards, training, and resolution of difficulties in reciprocity and jurisdiction.

## Strengthening the EMS System

Despite its remarkable achievements to date, the EMS system has one Achilles' heel: an apparent lack of strength, stability, and recognition in much of the administrative structure.

Much of the EMS system has been founded on grantsmanship, and the positive results of grantsmanship are often of precarious durability. There is also the danger that the EMS system's administrative structure will be damaged by opportunism and proliferation of duplicative effort in the field. The EMS system now needs a cohesiveness and structure that will nurture leadership, help achieve the necessary legislation, and coordinate all the players toward the common goal.

*"The road that stretches before the feet of a man is a challenge to his heart long before it tests the strength of his legs."*

*—St. Thomas Aquinas*

**OBJECTIVE:**

To firmly establish prehospital emergency medical services in the societal structure of the Nation, with recognized and stable leadership and administration.

**MEANS:**

A. Permanent State administrative heads of EMS and off-line medical directors.

B. Completed establishment of Federal Regional EMS Councils and a National Coalition of EMS participants.

C. Achievement of universal recognition and application of uniform standards and quality of care.

D. State and Federal legislation that will ensure identified, uniform quality care and system structure.

E. Recognized uniform application of standards and guidelines for care and services under the Star of Life emergency medical care symbol, including standard vehicle colors and markings.

## Communications

The most important aspect of EMS communications is that of EMT-to-physician. The National Highway Traffic Safety Administration has initiated and developed and currently sponsors and coordinates a system of medical communications that encompasses ten UHF radio channels. The NHTSA system is one of maximum orientation to patient care concerns.

One potential impediment inherent in current communications systems is that of system-imposed time sharing. It will prove to be increasingly unacceptable in the future because of the risk to the patient that occurs when doctor/paramedic communication is disrupted. Infrequent technical disruptions can be overcome; but accepting built-in limitations merely because "it's cheap and it works" is inexcusable.

The crying need of good EMS system communications is first, that the public can get in touch with the EMS quickly; second, that the dispatcher can send a first responder to the scene within 5 minutes; and third, that physician-to-paramedic communications be efficient and continuous—in other words, that a good patient-EMS-physician communications system be properly coordinated with other public service agencies.

**OBJECTIVE:**

To achieve nationwide State-by-State EMS communications systems that get patients into the system quickly and ensure that doctors can give online medical direction to paramedics continuously.

**MEANS:**

A. National 911 emergency number for all citizens.

B. Citizens' band (CB) listening base for all citizens (National Emergency Aid Radio [Near] program).

C. Continued communications planning and implementation for dedicated communications, in accordance with DOT nationally coordinated and published criteria.

## Management and Evaluation

How may one judge the impact of an EMS system? The significant factors include reduced numbers of fatalities, reduced numbers of complications and disabilities, a reduced socioeconomic impact, and reduced time of patient suffering. And a related consideration: How may one judge the *improvement* of an EMS system? Here, we want to achieve reduced response time, improved emergency care, improvement in injury prognosis, and evidence of improved EMS resource management.

Every evaluation process comprises first, data collection; and second, data review and analysis. In data collection, one first determines what constitutes the most significant elements, and then designs collection instruments that are neither burdensome nor complex. Finally, coding, card punching, and disk/drum storage (for random retrieval) must be provided for and conveniently set up.

In an EMS response system, the source of data is twofold. First is each ambulance sortie, from time of call to time of return, complete with a detailed, accurate record of significant events. Second is the record on each patient, complete from the time of the accident to the time of discharge or the completion of the autopsy. Means must also be found to integrate the data from the ambulance service, the hospital records, the autopsy report, the accident investigation, and the safety design features of the vehicle. These data, and the evaluation thereof, are essential to measure the efficiency of the total system as well as to provide the data for research, problem identification, and systems upgrading.

Data review and analysis wraps up the evaluation effort. For efficient evaluation, first provide for a frequent printout and review of the data to verify its completeness and accuracy. Planning for programing and analysis can be begun using these printouts; this can then be followed by chart or graph development to give a visual projection. The final steps are decisionmaking and policy or criteria development:

A common, nationwide EMS system and data element identification are desirable, but to date, progress has been slow.

**OBJECTIVE:**

To achieve an ongoing system of evaluation for quality control, management of resources, credibility of service, and optimum working of the EMS system.

**MEANS:**

Aid individual EMS system evaluations through data collection studies and technical assistance.

# Unit 4. Prehospital Emergency Medical Care Identification

## *The "Star of Life" EMS Symbol**

Since congressional enactment of the Highway Safety Act of 1966 and approval of Standard 11, "Emergency Medical Services," the Department of Transportation has vigorously pursued the implementation of a national prehospital emergency medical care system—a program that seeks to reduce the number of deaths and the degree of illness among the sick and injured, through effective medical intervention and care both at the scene of the medical emergency and during transit to definitive care.

Field intervention medicine is an entirely new service in the civilian structure of the United States, with a new set of standards, concerns, and quality of care for the victims of medical emergencies. It is being emulated around the world. Therefore, it is most appropriate that EMS be distinctively identified for the benefit not only of those working in this vital area, but also of the general public—potential users of the system.

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* "Star of Life" Emergency Medical Care Symbol, Department of Transportation (DOT-HS 803 721), January 1979. This brochure provides background, specification, and criteria regarding the symbol's current uses. It may be obtained from U.S. DOT/NHTSA, General Services Division, 400 7th Street, S.W., Washington, D.C. 20590.

Thus, in 1973 DOT adopted the "Star of Life" emblem as a symbol of this new service, of its distinctiveness, quality and credibility. EMS goods, services, components, and functions all become interwoven in the process of system development. The use of the "Star of Life" symbol by both the private sector and the government thus far has not only served to identify emergency medical care; more importantly, it has contributed greatly to the process of identity, encouragement, achievement, realignment of objectives, and commitment to improved emergency medical care. Both the States and Federal agencies have been authorized to assist in exercising supervisory control over the use of this symbol. In addition, steps are being taken to have the symbol appear on highway signs to help alert citizens about the EMS system and how to enter it and use it.

### Ambulance Colors and Markings

When an ambulance is easily and unmistakably recognizable, it is an aid to traffic safety and reduces the need for excessive dependence on lights and sirens. An early DOT/EMS study, "Ambulance Design Criteria" by the National Academy of Sciences, recommended that specific colors and markings for ambulances be adopted and standardized nationwide. Later, the General Services Administration and DOT developed and published the Federal specification for ambulances (1974: KKK-1822). The standard color is white; the standard markings, an orange stripe, blue lettering, and the "Star of Life" symbol. It is also considered preferable that any added lettering be kept below the orange stripe (band) so as not to distract from the basic markings, since such lettering is primarily of local interest only and of little significance to the victim of an emergency or the passing motorist. For maximum effectiveness of these standard colors and markings, of course, they must not be duplicated on non-ambulances.

These standard colors and markings produce a highly visible ambulance, which in turn means the vehicle may be operated more safely in any light and against any background. They also mean that the ambulance may be operated more safely because people everywhere can quickly recognize it as such and respond appropriately. Adoption of these colors and markings nationally is therefore important not only so that the public may recognize the EMS system as a distinctive service dedicated to quality health care and so that the public safety is guarded; but it is also important because the ambulances built to Federal specifications have body configurations that resemble commercial vehicles—the color scheme thus becomes the primary factor in promoting rapid public identification. Highly visible and rapidly identifiable ambulances also reduce the need to depend on lights and sirens, which are not conducive to good patient care when used to excess and in some cases without justification.

## Unit 5. Issues Concerning the Emergency Medical Technician

### *Medical Ethics*

The word "ethics" comes from the Greek word meaning character. Professional ethics set standards of rightness and wrongness of human conduct in a profession, but do not necessarily concern themselves with morality. For example, it is not ethical for a nurse to express to a patient an opinion concerning a doctor's real or perceived faults (nor, for that matter, for a doctor to do so of a nurse). Neither is it ethical for one physician to attend another's patient unless invited by the other to do so. These acts are not immoral, but they are unethical.

When faced with situations that call for a choice of behavior, one must act ethically. Specific situations that paramedics are likely to face include preserving life, meeting the needs of patients when they are unable to pay, and requesting other medical help when that help is needed.

A code of ethics is a list of rules of ideal conduct, drawn up by responsible members of a particular professional group and meant to be followed by all members of that group. Aesculapius wrote the first medical code of ethics; since then, many more have been written.

*A Code of Ethics for Emergency Medical Technicians* was issued by the National Association of Emergency Medical Technicians in January 1978. This *Code* states:

> Professional status as an Emergency Medical Technician is maintained and enriched by the willingness of the individual practitioner to accept and fulfill obligations to society, other medical professionals, and the profession of Emergency Medical Technician. As an Emergency Medical Technician, I solemnly pledge myself to the following code of ethics:

- The fundamental responsibility of the Emergency Medical Technician is to conserve life, to alleviate suffering, and to promote health.
- The Emergency Medical Technician provides services based on human need, with respect for human dignity, unrestricted by considerations of nationality, race, creed, color, or status.
- The Emergency Medical Technician does not use professional knowledge and skill in any enterprise detrimental to the public good.
- The Emergency Medical Technician respects and holds in confidence all information of a confidential nature obtained in the course of professional work unless required by law to divulge such information.

- The Emergency Medical Technician as a citizen understands and upholds the laws and performs the duties of citizenship; as a professional person the Emergency Medical Technician has particular responsibility to work with other citizens and health professions in promoting efforts to meet the health needs of the public.
- The Emergency Medical Technician maintains professional competence and demonstrates concern for the competence of other members of the medical profession.
- The Emergency Medical Technician assumes responsibility in defining and upholding standards of professional practice and education.
- The Emergency Medical Technician assumes responsibility for individual professional actions and judgment, both in dependent and independent emergency functions, and knows and upholds the laws which affect the practice of the Emergency Medical Technician.
- The Emergency Medical Technician has the responsibility to participate in the study of and action on matters of legislation affecting Emergency Medical Technicians and emergency service to the public.
- The Emergency Medical Technician adheres to standards of personal ethics which reflect credit upon the profession.
- The Emergency Medical Technician may contribute to research in relation to a commercial product or service, but does not lend professional status to advertising, promotion, or sales.
- The Emergency Medical Technician, or groups of Emergency Medical Technicians, who advertise professional services, do so in conformity with the dignity of the profession.
- The Emergency Medical Technician has an obligation to protect the public by not delegating to a person less qualified any service which requires the professional competence of an Emergency Medical Technician.
- The Emergency Medical Technician works harmoniously with, and sustains confidence in, Emergency Medical Technician associates, the nurse, the physician, and other members of the health team.
- The Emergency Medical Technician refuses to participate in unethical procedures and assumes the responsibility to expose incompetence or unethical conduct in others to the appropriate authority.

Both the *Code of Ethics for Emergency Medical Technicians* and similar oaths express a very basic concept: concern for the welfare of others, from which all statutes of right and wrong ultimately arise. It is safe to say that if EMT–P's place the welfare of the patient above all else when providing medical care, they will rarely commit an unethical act.

### Medical Practice Acts

Every State has laws, regulations, or written policies that govern or impact an EMT–P's actions. In most areas, these rules of practice take the form of a Medical Practice Act that defines the minimum qualifications for those who may perform medical procedures and provide a means of certification for different categories of health professionals.

Although currently medical practice acts dominate health care rulemaking, more and more States are developing and passing specific legislation to cover all phases of EMS, including the training, certification, and licensure of EMT–P's. When a State or area has a medical practice act or specific EMS legislation, paramedics must be familiar with such laws.

### Good Samaritan Laws*

Many States have implemented "good Samaritan" laws to protect physicians and other medical personnel from legal actions that may arise from emergency treatment not in the line of duty. The typical good Samaritan law requires that persons responding to an emergency do all that they can within their abilities to sustain life and to prevent further injury.

Paramedics are not expected to function as physicians; they are expected to use those skills that they have been specifically trained to perform. But paramedics EMTs and First Responders *are* expected to do all they can to sustain life, prevent further injury, and ease suffering within their level of competence. Good Samaritan laws are designed to protect paramedics who follow their code of ethics.

Good Samaritan legislation does *not* protect an individual from responsibility for negligence. Negligence is a complex issue. In order to prove negligence, a person must demonstrate that an injury occurred; that the person accused of negligence failed to act as another prudent person with similar training would have acted under the same circumstances; and that this failure to act appropriately was the cause of the injury. The lesson here is that in most places EMT–P's are protected from liability as long as they adhere to the standards established for them.

## Professional Criteria

Many codes, standards, criteria, and guidelines have been established concerning vehicle design and equipment as well as training and operational procedures, by such groups as the National Research Council, professional groups, and NHTSA. While these are not laws, they can be introduced as evidence in a lawsuit and may affect the results of the suit. Therefore it is in the EMT–P's best interests, as well as of the EMS system as a whole, to make sure that all aspects of both service and its components (communications, operations, training, ambulances, equipment) are developed and maintained according to current national standards.

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* There is a full discussion of good Samaritan legislation in Unit 6.

## Duty to Act*

The Duty to Act doctrine requires that ambulance operators who do not charge for their work—including public, municipal, and volunteer services—to respond to every call for help. The doctrine does not, in most cases, apply to *private* ambulance services, which are usually permitted to select patients and answer calls as they choose.

## Consent*

Paramedics, like physicians, must gain the patient's consent to receive emergency care or incur charges of technical assault and battery. Several standards (depending on the patient's age and condition) exist governing the various forms of consent and the ways in which it may be given:

- Consent must be informed; that is, the patient must understand the nature and extent of the procedures to be performed and the risks involved.
- Consent must be obtained from every conscious, mentally competent adult.
- Consent is implied for emergency lifesaving treatment to the unconscious adult.
- Consent must be obtained from the parent or guardian of one who is a child, as legally defined by the State, or of one who is adult but is mentally incompetent. If a parent or guardian is not available, emergency treatment to maintain life may be undertaken without consent.
- Consent refused by a conscious and mentally competent adult means that the patient may not be treated without a court order. In such cases, the paramedic should consult the physician for instructions. Generally, the wisest approach is to inform the patient of the consequences of refusing treatment. If the patient understands these consequences and still refuses treatment, there is little that may be done.
- Psychiatric emergencies present difficult problems of consent. Under most conditions, a police officer is the only person with the authority to restrain and transport a person against that individual's will. The EMT–P should not intervene unless directed to do so by a police officer or unless it is obvious that the patient is about to do life-threatening harm to himself/herself or others. Neither the physician nor the patient's family may authorize the actual transport and eventual confinement of a psychiatric patient. The physician and family may authorize involuntary commitment for psychiatric treatment, but their authority does not extend to transport of a patient by force and without consent. Thus, it is important that each EMS system establish procedures for dealing with psychiatric emergencies based on local laws and policies. In most cases police involvement will be required.

## Abandonment

A doctor abandons a patient by ending the physician-patient relationship in mid-treatment, without the consent of the patient, without allowing the patient enough time to find another physician, and with adverse results to the action. For abandonment to occur:

- There must have been an initial physician-patient relationship.
- The physician must have ended the relationship without the patient's consent.
- The physician must have ended the relationship without allowing the patient enough time to obtain another physician's services.
- The patient must have had a continued need of medical treatment.
- Injury or death must have resulted from the termination of the physician-patient relationship.*

Although the above definition is stated in terms of the physician, EMTs—the agents of a physician—are clearly involved as well. In other words, once the EMT–P has responded to an emergency, he or she must not leave a patient who needs continuing medical care until another competent health professional takes responsibility for the patient. This may seem like an obvious requirement; but there have been cases where critically ill or injured patients were left at a hospital emergency department and died before emergency department personnel took adequate notice of them. Thus, the EMT–P must stay with the patient until an orderly transfer of care has taken place. The patient should never be passed from a greater to a lessor competence level in the pre-hospital care sector or from the pre-hospital care sector to the emergency department in the EMS continuum or evacuation chain.

## Medical Direction

An EMT–P's actions in the field are considered the delegated actions of a physician; that is, although the paramedic is the one who performs the medical procedures, such actions are still legally those of a physician, and the physician is legally responsible for them. For this reason, many activities cannot be carried out without an order from a licensed physician. Orders may either be given by radio or be defined by protocols (standing orders). In any case, EMT-P's are not free to disregard or to go against a doctor's orders. This may lead to difficult situations. For example, a physician who may not be knowledgeable about prehospital emergency care may be present at the scene of a medical emergency and may give orders that the EMT-P feels are inappropriate for the particular circumstances. However, paramedics are on very shaky legal ground if they choose to disregard such orders. It is best for the medical director of the EMS system to develop policies defining the EMT-P's relationship with the medical director and with other doctors in the community. When conflicts arise between paramedics and physician-bystanders in the field, these problems should be resolved by the medical director, not by the paramedic. Both off-line and on-line medical direction are of major significance in well organized EMS systems.

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* Unit 6 contains a detailed discussion of this.

* Chaylet, 1969.

### Death and Dying

As a paramedic, you will constantly be exposed to difficult and painful emotional experiences. You will see the suffering, mutilation, and unavoidable death of other human beings. It is only natural that such experiences lead to feelings of anxiety and sadness, as well as a desire to suppress such uncomfortable feelings. Those who have lost persons close to them may have their old feelings of sadness rekindled by this daily contact with pain and dying.

It is important for you to realize that such feelings are expected. It is not unusual to feel sick at the sight of mutilating injury or to become anxious in the presence of death: Such feelings mark the sensitive person.

As you gain experience in the field, you will learn to control these feelings while caring for patients. At the same time, you should also learn to be tolerant of yourself and not to feel ashamed or embarrassed because you are affected by tragedy. By understanding your own feelings in these situations, you will be better able to deal with the feelings of the patient, the patient's family, other emergency personnel, and bystanders; and they, in turn, will be less hesitant in confiding their worries to you.

## Unit 6. Synopsis of Legal Considerations in Prehospital Care*

### Introduction

There are certain inherent limits to any discussion of the legal aspects of prehospital care. First, "the law" encompasses regulations, statutes, and judicial decisions at the Federal, State, and local level, many of which seem to change almost daily. Second, most relevant legal problems in prehospital care involve questions of State law, and thus "the law" applicable to a given situation may vary dramatically from State to State and jurisdiction to jurisdiction. Finally, a proper legal decision in a given case necessarily depends on the facts—and even a slight change in the facts may produce a completely different legal result. For all these reasons, the following general comments on the laws applicable to prehospital care should not, cannot, indeed must not be thought of as a substitute for the individual legal advice of a competent attorney in the jurisdiction in which the EMT practices.*

The basic legal considerations of prehospital care are: The question of consent; common theories of liability and responsibility for patient care; and individual responsibilities in claims prevention, counseling, and therapy.

### Patient Consent and the Law

Consent for treatment or transport is the first consideration in every encounter between the EMT and the patient. In the past, the legal concept of consent has, regrettably, been bound up in rumor, myth, and half-truth. Accordingly, it is necessary to discuss the concept of consent, particularly as it applies to emergency medical services.

The word "consent," in a medical-legal context, describes a situation in which the patient has given permission for treatment. Generally speaking, consent may be either "expressed," in the sense that it is affirmatively communicated by words or actions; or, under certain limited circumstances, consent may be "implied" by legal presumption. It is imperative that the patient's consent be obtained before treatment is begun because:

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* The Department is both grateful and fortunate for the time and effort applied by Mr. R. Jack Ayres, Jr. in the preparation of Unit 6. Jack Ayres is a distinguished member of the Texas Bar and maintains a busy trial practice in Dallas. In addition, he is a consultant to the Director of Emergency Medical Services, Texas Department of Health; a consultant to the North Central Texas Regional EMS project; and a consultant to the City of Dallas Hospital. Jack Ayres is also a guest lecturer at Southwestern Medical School (University of Texas) and Parkland Memorial Hospital's Continuing and Staff Education programs and an instructor on the legal aspects of emergency medical services at the University of Texas Health Science Center at Dallas.

In keeping with his long-term interest in medicine, Jack Ayres undertook and completed the Dallas paramedic training program. He maintains his skills by riding shifts with Dallas paramedics when he is not engaged in his law practice or lecturing. Due to his real-world experience with both EMS and the law, coupled with a lively style of presentation, Jack has become a popular speaker at EMS conferences and seminars.

Jack Ayres received his Bachelor of Arts degree from Baylor University. He received his Juris Doctor degree from Baylor in 1971, after achieving the Dean's Distinguished List, the Harris Honor Society, and the Order of Barristers. Since 1977, he has made numerous presentations on a wide variety of legal, medical-legal, and EMS topics.

* Because the material in Unit 6 is equally applicable to ambulance drivers, paramedics, doctors, nurses—all medical practitioners in the EMS system—the initials EMT are used throughout this unit as a generic term.

- The patient's constitutional right to accept or refuse treatment must be scrupulously observed by all concerned;
- Treatment of a patient without consent may give rise to potential civil and criminal liability (including the charge mentioned in Unit 5, technical assault and battery); and
- An EMT's knowledge of the law of consent reduces or precludes delay in initiating patient care.

## A System for Determining Consent

There are three levels of consent. The highest and best level is voluntary consent, commonly referred to as expressed consent. It is an agreement, conveyed by words or actions, between the EMT and the patient as to the scope and course of the patient's treatment.

The second level is involuntary consent, in which the patient's consent is supplied by the process of the law itself. Common examples of people who may be treated although their consent was involuntary include patients in the custody of the law who have been charged with specific offenses by warrant or indictment, or patients who are being treated by court order, such as the mentally ill or other persons in the custody of the State.

The final level of consent—and it is consent of the last resort—is implied consent, which arises when the patient is unable to communicate the wish for treatment.

The essence of a systematic approach to obtaining consent in the field lies in thoroughly analyzing and exhausting all possibilities of consent at the first level before proceeding to the second; and at the second, before proceeding to the third. If you follow this stepwise approach, the chances of making a mistake in determining consent are much smaller—to the benefit of all concerned.

Your first step is to determine whether the patient is an adult or a minor according to the laws of your State. Generally, an adult is considered to be anyone over the age of 18, anyone who is or has been validly married, or anyone who has been wholly or partially emancipated (declared an adult) by court order. All other persons are minors.

### THE ADULT

The first level of the systematic approach, again, is to seek voluntary consent. Here, the EMT simply asks or responds to the patient's request for treatment. By offering treatment or by accepting the patient's request for treatment, you are basically creating a contract; and when such consent has been obtained and maintained, no further action is required.

If you are unable to get a voluntary consent for treatment, it is time to proceed to the second level: involuntary consent. The circumstances in which you may treat a patient against that patient's will are very limited—you may do so if ordered to by a court, or, in an extreme emergency, if ordered to do so by a peace officer who has the patient under arrest. Additionally, the scope of treatment in involuntary consent is also very limited and varies from jurisdiction to jurisdiction. In general, involuntary consent does not permit you to give general or palliative care (i.e., to treat a *non*life-threatening injury or illness) without the specific order of a court.

If you are unable to obtain either voluntary or involuntary consent, there is one final recourse: implied consent. To obtain implied consent:

- The patient must be unconscious; and
- The patient must be suffering from a life-threatening disease, illness, or injury.

It should be emphasized that *both* of these elements are required for implied consent. The truly unconscious patient is unable to maintain protective reflexes, including a patent airway. Accordingly, any truly unconscious patient would by definition be suffering from a life-threatening disease, illness, or injury.

### THE CHILD

The systematic approach to obtaining consent also applies to the treatment of children, with some modifications. Generally, children may not legally consent to their own treatment. Thus, in order to pursue the first level—voluntary consent—the EMT must identify one of two subcategories: special circumstances or surrogate consent, consent by another on the child's behalf.

When dealing with a child, you should first find out whether or not there are special circumstances that would let you treat the child with the child's own consent. Common examples are a child on active duty with the armed forces of the U.S.; a pregnant child; a child suffering from venereal or other serious contagious disease; a victim of child abuse (which in most States includes not only physical beating, but also mental or emotional neglect or abuse); or the so-called emancipated minor.

Most of these special circumstances are self-explanatory. Some notes are in order, though. If you suspect child abuse, you should be aware that most States make it a criminal offense to fail to report circumstances that give rise to a good-faith belief that a child has been physically, emotionally, or mentally abused. With regard to emancipation: A child may be wholly or partially emancipated by court order. In the field, you may consider a child "emancipated" for the purposes of consenting to medical treatment in most jurisdictions if the child is 16 or 17 years old and lives away from home, without being substantially dependent upon parents for financial support.

If the child does not meet a special circumstances, it is necessary to obtain substitute or surrogate consent. For substitute consent, the purpose of the law is to be certain that only a person standing in a special relation to the child may authorize the child's medical treatment—generally, a natural parent (blood relation) or a court-appointed guardian. It should be emphasized that the parental right to consent is limited to the *natural* parent. Stepparents or foster parents are not included in the parental right to consent unless such individuals have other rights to consent as discussed below.

Every reasonable effort must be made to locate a natural parent to give voluntary consent for the treatment of a child. In some States, if a parent cannot be readily located, consent may be given by a natural grandparent, a natural aunt or uncle, or an adult sibling. Also, in some States the natural parent may authorize the child's treatment by signing a particular written instrument in the form and manner required by statute or case law.

In obtaining consent to treat a child, keep the following general rules in mind: First, try to find a natural parent to give consent. Either natural parent may consent; and the law only requires the consent of one parent. (If the parents are divorced, and if there is a conflict between the parents about treatment, generally the parent who has custody or conservatorship of the child will have the prevailing right to consent.) If there is no natural parent, seek the court-appointed guardian, who may be a stepparent or foster parent. If neither natural parent nor court-appointed guardian is available, some States will allow consent to be given by an adult who is closely related to the child by blood—grandparent, aunt, uncle, or sibling.

In the absence of any of these relations, the next level is involuntary consent. Involuntary consent for the child is very similar to that for the adult, with one addition. The child may be treated by court order or by the order of a police officer who has custody of the child; the child may in addition be treated by order of a child welfare worker who has custody of the child. As with the adult, involuntary consent for the child is usually permitted only under limited emergency conditions specified by State law.

The final level is implied consent, and usually only one element is required: The child must be suffering from what reasonably appears to be a life-threatening condition or illness. There is no requirement that the child be unconscious because in obtaining consent the child's ability to communicate is immaterial.

The next section will discuss special problems in consent. It is important to note here that implied consent to treat a child does *not*, as a rule, override one of these special problems, such as a parent's refusal to consent.

## Special Problems In Consent

Occasionally the EMT will encounter a patient or others who resist or oppose treatment. Fortunately, this happens rarely; but you should be able to recognize the problem immediately and know how to deal with it effectively and appropriately.

The first thing is to set aside everything you may have heard or learned from the "grapevine" about the law applicable to such cases. Only a handful of medical and nursing schools in the United States provide their students with any significant amount of legal training. As a result, many of the decisions that ought to be made on the basis of the law are instead made on the basis of gossip, rumor, or misunderstood "policy"—and this applies to doctors, nurses, and EMT's alike.

The second step in effectively dealing with prehospital legal problems is integrating fundamental principles of behavior assessment and modification into the process. Almost without exception, the patient who resists or opposes treatment has mental or emotional difficulties at least as incapacitating as the physical problems for which treatment is needed. Unless the EMT can assess and deal effectively with the mental as well as the physical component of a patient's problem, it may be impossible to obtain consent, or treatment may be fragmented and ineffective.

Unfortunately, too many health care professionals confront the "problem" patient inappropriately. If you are aggressive or hostile, the patient's anxiety and tension will increase; the response may even be catastrophic.

It is altogether understandable that in these days of emergency medicine "burnout," many EMTs may feel frustration, exasperation, or even outright anger when dealing with the "problem" patient. In such a situation, you must assess your own feelings and step back—you must approach the case professionally rather than personally. Only when you can confront, understand, and control your own feelings and attitudes can you treat the patient effectively.

The final step in dealing with special problems of consent is to determine what legal category the problem fits and to act accordingly.

### THE PATIENT WHO NEEDS BUT REFUSES TREATMENT

One of the most perplexing problems of prehospital emergency care today is that of the conscious, rational adult patient who is suffering from an actually or potentially life-threatening disease or illness, but who refuses treatment or transportation.

If, in the EMT's judgment, the patient is suffering from a truly life-threatening disease or illness, every reasonable and lawful effort should be made to convince the patient, or anyone who has any influence with the patient, to accept treatment or transportation. When a patient refuses consent, that means that you *may not* treat or transport the patient.

If the patient persists in refusing consent after you have made every reasonable and lawful effort of persuasion, this refusal should be carefully documented on the patient care form and signed by the patient and, preferably, witnessed by an impartial observer. Generally, police officers or others not directly involved in the case make excellent witnesses. The patient care form should contain a complete description of the patient's condition, the number and times of the requests made by the EMT, and the patient's responses thereto.

The law has recently undergone a revolutionary change concerning the rights of patients, particularly institutionalized mental patients, to refuse consent. Under the new laws, it is extremely hazardous to attempt to force the patient to submit to treatment; those who do may be subject to suits for assault. Some EMS systems have used experimental programs wherein, if a patient refuses consent and death is imminent, a court may order treatment. Although these systems have generally been successful in initiating treatment under very adverse circumstances, they have yet to be tested in the courts.

## THE PARENT WHO REFUSES PERMISSION TO TREAT A CHILD WITH A LIFE-THREATENING ILLNESS

Very rarely, the EMT will encounter a parent who refuses permission—usually on moral, ethical, or religious grounds—to treat a seriously ill child. The case of a child who suffers from a life-threatening disease or illness is, under State law, very different from that of an adult. The courts will generally intervene to require emergency treatment for a child; it is usually difficult to impossible to obtain a similar court order for an adult.

When a parent refuses permission to treat a child, every effort must be made to convince the parent of the seriousness of the problem and the necessity of treatment. If you do not succeed, you should summon the police and make every effort to have the court juvenile authorities order the child's treatment. Such procedures vary from State to State, but they should be known to the district attorney or attorney general of the State in which you practice.

## THE MENTALLY ILL PATIENT

Under the law, individuals who by reason of mental defect or disease are unable to handle their own affairs and need supervision by the court or other qualified person are called *non compos mentis* (not of sound mind). Trying to determine whether someone is mentally incompetent or so irrational as to require court-ordered supervision is one of the most difficult and complex of all medical-legal procedures and decisions. Although every State has a procedure for both voluntary and involuntary commitment of someone who is mentally ill, there is no reliable way of determining mental competence in the field. As a rule only a doctor is qualified to declare that a patient is mentally incompetent and to order medical treatment over the patient's objections; and even physicians may disagree in given cases.

On confronting a mentally ill patient, the EMT should first encourage the patient, if at all possible, to seek treatment in terms of voluntary commitment. If the patient cannot be convinced, involuntary commitment procedures may be required. Almost all these procedures require a formal, written application to a court or law enforcement authority, coupled with either a court order of commitment or a warrant of confinement or arrest. Generally there are stringent limitations on the length of time an individual may be confined under such orders, and the procedures involved are complicated and difficult to understand. Suffice it to say that only under the orders of a court or a law enforcement officer is the EMT justified in instituting treatment.

## THE INTOXICATED OR BELLIGERENT PATIENT

As an EMT, you will frequently encounter people who are in some stage of drug or alcohol intoxication. The effects and characteristics of acute drug or alcohol intoxication are a medical and social phenomenon that is well understood by all health care providers. Not so well understood, however, are the serious legal consequences that follow from dealing with such patients.

If an intoxicated person refuses treatment, follow the method for handling and documenting the refusal outlined earlier: Make every effort to persuade the individual to consent to treatment voluntarily; if consent is still refused, make sure that the patient care form is minutely documented and have it signed by the patient and by an impartial witness.

If the intoxicated person consents to treatment, take the greatest possible care. Alcohol or drugs may mask vital symptoms, so that the seriously injured patient who is also intoxicated has a much higher than average risk of death or disability. For example, take exquisite care to document your review of neurological functions and changes in levels of consciousness. If an intoxicated patient has a closed head injury (wherein the skin is not broken) you must take even more particular care.

The principle barrier to good care of the intoxicated patient—and the greatest single risk to you—is that you will get turned off by the patient's appearance or attitude and will overlook symptoms that could be vital. A good rule of thumb might be: The more disgusted you are, the more careful and minutely thorough you should be.

### THE PATIENT WHO GIVES AND THEN WITHDRAWS CONSENT FOR TREATMENT

The patients who give and then withdraw consent for transport or treatment usually do so because they feel that the therapy being given is invasive or undesirable—it may hurt too much or violate a principle. As a rule, you may only treat a patient for as long as the patient effectively consents; so when a patient changes his or her mind, you will have to make a "judgment call." Usually you will have to discontinue treatment when the patient asks you to, and then attempt to convince the patient of the need to continue.

If, however, it is medically inappropriate to discontinue therapy, you should consult the EMS medical director or another responsible physician rather than getting into a physical confrontation with the patient—physical confrontations should be avoided at all costs. Restrain a patient against the patient's will only when medically ordered to do so and when it is absolutely necessary for medical reasons. (You should, of course, use only the minimum possible force or restraint; and it should never be used punitively.)

### THE DECISION TO RESUSCITATE AND "NO CODE" ORDERS

Some signs of clinical death are obvious to anyone; others are not.

As an EMT, you will occasionally run into situations where a decision will have to be made as to whether to resuscitate a given individual. Even more rarely, you may encounter a "no code" order—a case where the patient's attending physician has medically determined that, because of an underlying disease that has reached an advanced state, a patient whose heart or breathing stops should not be resuscitated.

In any event, when a patient is a candidate for CPR you have at least implied consent; and this consent controls over the authority of anyone present—even a family member—except the patient's physician.

Most EMS systems require that you resuscitate a patient who is without spontaneous breath or pulse unless there is *absolutely* no possibility that the patient is alive—e.g., the patient has been decapitated, there is multiple dismemberment with crushing, etc.; the body is decomposed; or rigor mortis is present. *It cannot be overemphasized that deciding whether or not a patient "ought" to be saved—even on humane grounds—is NOT your job.* If there is even the slightest chance that a patient might still be alive, your job is to give vigorous resuscitation until the patient is pronounced dead in the physical presence of a physician. Similarly, a doctor should not give, and an EMT should not be asked to follow, "no code" orders, except under the most limited circumstances—for example, if the patient's personal physician is right there with you and can make an accurate judgment based on the specific circumstances.

Letting someone die who otherwise might have lived is inexcusable. There can never be a satisfactory explanation. There is no margin for error.

## Theories of Liability

There may come a time when a patient or a survivor of a patient feels that you, as an EMT, gave that patient inappropriate care. Such an individual has the constitutional right to institute a legal action against you and anyone else thought to be legally responsible. Thus it is important for you as an EMT to have an accurate understanding of the judicial process—including not only the patient's rights, but also your own.

A legal action like the one described above is called a civil suit. The wrongful act that gives rise to the civil suit is called a tort. A civil suit is instituted by a private individual against another private individual, and the goal it seeks is generally some kind of repayment (called "damages"); usually monetary, but sometimes in another form at the discretion of the court.

Occasionally, the same conduct (tort) that gave rise to the civil suit may also give rise to a criminal suit—an accusation that you violated the criminal laws of either the United States or of the State in which you practice. In such a case, if a criminal complaint is filed with a law enforcement authority you may have to face a criminal suit in addition to the civil suit. In a criminal case, the government has to prove beyond any reasonable doubt that the defendant is guilty; if it is successful, the defendant can, at the discretion of the court, be punished by fine, imprisonment, or both. In a civil case, the plaintiff (accuser) only has to prove that the greater weight and degree of creditable or believable testimony favors the plaintiff's position; if the plaintiff is successful, he or she can only recover money damages or related legal relief.

There are many theories of liability that can apply to the delivery of prehospital health care. EMT's should be familiar with these theories—the better to avoid them.

### ASSAULT AND BATTERY

In common law, an assault occurs when the defendant without privilege or excuse threatens an unlawful invasion of the plaintiff's right to bodily security—whether or not the threat is actually carried out. A parent threatening to spank a child is not committing assault; a person who announces, "I'm going to punch you out" or "I'm going to tie you up," is assault.

Battery, on the other hand, is committed when the defendant without privilege or excuse touches or has contact with the plaintiff's body or with an item closely related thereto, such as clothing or articles the plaintiff may be carrying. Technically, for example, purse-snatching is also battery.

It is easy to see, therefore, that virtually all acts of medical treatment may be considered either assault or battery if they are undertaken without consent. Assault and battery are good examples of the absolute need for patient consent before treatment is begun.

## FALSE IMPRISONMENT

False imprisonment occurs when the defendant without privilege or excuse restrains the plaintiff's right to freedom of movement—for example, kidnapping, which is a crime, can also be a tort, in some States, since kidnapping involves the restraint of freedom of movement plus demands for money. In field medicine, charges of false imprisonment may be brought if the EMT transports a patient without consent or uses restraints wrongfully. Once again, obtaining adequate patient consent—whether voluntary, involuntary, or implied—gives you the privilege you need to provide care and treatment.

## INVASION OF PRIVACY AND DEFAMATION

The law recognizes that people have the right to their own personal lives, and there are two torts that are based on this right: invasion of privacy and defamation. Both consist of making disclosures about someone's personal life that ought not to be made.

Defamation consists of making an untrue statement about someone's character or reputation without privilege or consent. If the defamation is made orally, it is called slander. If it is made in writing or by the use of mass media, it is called libel.

The courts also frequently recognize the tort referred to as invasion of privacy. An invasion of privacy occurs when the defendant finds out private or personal information about the plaintiff and in some fashion reveals this information, or allows someone else to reveal it, so as to cast the plaintiff or the plaintiff's family in a false or ridiculous light to the public. With defamation, the statement has to be false; with invasion of privacy, it may be a statement that is perfectly true but conveys a false impression or holds someone up to ridicule—for example, letting it be known that Person X won't take a bath without the accompaniment of a rubber duck.

Almost every day, EMT's confront situations in which they become privy to a wealth of information that is confidential and that would be extremely embarrassing to the patient or the patient's family if it were publicly revealed. It is important that you be extremely cautious about communicating the information you get while caring for someone—including not discussing it with unauthorized individuals or without the knowledge or consent of the patient or the patient's family; even being scrupulously careful about what you write on your patient care forms and in other medical records. The best policy is generally not to discuss what you know with anyone other than someone who has a *medical need* to know *medical* information.

## CIVIL RIGHTS

Most States as well as the Federal government have comprehensive laws that prohibit discrimination in granting or denying health care services to a patient by reason of the patient's race, color, sex, national origin, or, in some cases, the patient's ability to pay for the services rendered. It is imperative that all health care professionals understand that a patient's right to emergency medical treatment may not be reduced or denied because of any of these factors. If a given health care provider were to contemplate basing a method of treatment, for example, on whether the patient had adequate insurance coverage, it would be well for the provider to consult a knowledgeable attorney to be certain that no violation of the law is committed.

## NEGLIGENCE

By far the most common charge an EMT will face is that of professional negligence, sometimes called "malpractice," "misfeasance," or "malfeasance" (all of these are based on the Latin for "wrong conduct").

The circumstances under which a patient may win a civil suit charging negligence vary from State to State. In general, however, the plaintiff must plead, prove, and obtain a favorable finding by the jury or the court that:

- The defendant had a legally recognized *duty* to provide health care to the plaintiff;
- The care the defendant provided to the plaintiff was substandard, and thus a *breach of duty*;
- The defendant's breach of duty was a *proximate cause* of damage to the plaintiff; and
- The nature and extent of the results to the plaintiff did constitute *damages*.

These four factors are discussed in detail below.

## DUTY

In the claim of negligence, the concept of duty is simple: that there is a relationship between the defendant and the plaintiff that obliges the defendant to act toward the plaintiff in a certain way. Generally, a defendant has no obligation (or "affirmative legal duty") to undertake someone's medical care if there is no relationship between defendant and plaintiff based on professional function or medical need. Thus, for example, if you are off duty and outside your jurisdiction, you are probably not required to stop at the scene of an automobile accident to help a seriously injured patient unless your State has a law that holds otherwise. We say "probably" because the law is understandably eager to impose a duty in such cases—as is ordinary human feeling—and even a slight act by an EMT that could be interpreted as undertaking patient care could give rise to liability. For legal purposes, it may be assumed that whenever you are on duty, responding to a call in the course of employment, at the scene of a medical emergency, or participating in treatment, you have a duty to care for the patient.

### BREACH OF DUTY

Generally, you as an EMT will breach your duty to a patient if you fail to provide that type of care that would be provided by a reasonably prudent person having the same or similar training. There are two ways to violate one's duty ("breach" is a Middle English word meaning "break")—acts of omission and of commission. An act of omission is the failure to do that which a reasonably prudent person with the same or similar training would have done in the same or similar circumstances. An act of commission is engaging in an act or practice which a reasonably prudent person would *not* have done under the same or similar circumstances. Forgetting to put in an I V is an act of omission; injecting the wrong solution is an act of commission.

Proving breach of duty involves careful analysis of the standard of care that is owed to the patient. The standard owed is not that of a guarantee that the plaintiff ought to have received the best care available, but that the defendant must perform only in a reasonable fashion consistent with training under the circumstances. Generally, cases of health care liability in most jurisdictions require expert testimony to establish the standard of care and breach of standard of care.

### PROXIMATE CAUSE

The third requirement of a successful negligence claim is that the plaintiff prove that the defendant's breach of duty was a proximate cause of the damages sustained by the plaintiff. Proximate cause is a term embodying at least two concepts relative to medical care: cause in fact and foreseeability.

The concept of "cause in fact" reflects the law's requirement that the defendant be responsible only for conduct that actually results in injury or damage to the plaintiff. For example, suppose you were to yell "Fire!" in a theater: If the theater were crowded, panic ensued, and the plaintiff were injured, your shout may be a cause in fact of the injury. On the other hand, if the theater were empty or you were an actor on stage, there would be no cause in fact. Cause in fact usually becomes an issue in medical cases in which the plaintiff claims that the defendant gave treatment for an existing illness or injury and that instead of being palliative, the treatment resulted in disability or death. In such cases disputes may develop as to whether it was the original injury or whether it was the EMT's negligence that caused—was the "cause in fact"—the ultimate damage.

The other component of proximate cause is foreseeability. This means simply that the defendant ought reasonably to have known that the plaintiff would sustain injury or damage as a result of the defendant's conduct. A defendant will not be held liable for an injury sustained by the plaintiff, even if the injury was in fact caused by the defendant's conduct, *if* the injury or complication was so bizarre that no reasonable person situated as the defendant was situated could have foreseen what would happen.

### DAMAGES

Last, the successful plaintiff in a negligence suit must prove that there was damage. In health care liability claims, plaintiffs commonly seek repayment for physical pain and suffering, mental anguish, hospital and medical expenses, and sometimes loss of earnings and earning capacity; other items of damage may be claimed as well. An unfortunately high number of claims against health care professionals involve injuries to the brain or spinal cord or death; it is not unusual for the amount of damage in such cases to exceed two or even three million dollars. Interestingly, how much money is to be awarded to the successful plaintiff is peculiarly a function of the jury or judge in the initial civil case. Such a determination generally cannot be set aside on appeal unless it is grossly excessive or grossly inadequate by objective standards.

Most States allow the plaintiff to plead and prove a right to punitive or exemplary damages in two cases: gross negligence and willful or malicious conduct. Punitive or exemplary damages are not imposed specifically to compensate the plaintiff, but rather to punish the defendant or to deter others from committing similar acts by making the case an example.

Gross negligence is in most jurisdictions little different from ordinary negligence; it is a matter of quality or degree. The same facts that give rise to a claim for negligence may also give rise to a claim for gross negligence if the defendant's action were sufficiently reckless and improper.

Willful or malicious conduct involves the actual intention or desire to injure, and thus goes a step beyond either sort of negligence. Negligence by definition implies thoughtlessness or carelessness; malice implies the desire to see someone suffer.

## Individual Responsibility

EMT's have not only ethical and moral obligations to the public—they have a duty to the public as well. It is important that all EMT's understand the limits of their personal responsibility for patient care under the law.

## GOVERNMENTAL IMMUNITY

Hundreds of years ago, it was thought that sovereign rulers got their authority directly from God, and that the rulers—and by extension their governments—were answerable to no one for their conduct. This principle is called the doctrine of sovereign immunity, and arrived on this continent basically unscathed when the United States were formed. Over the years, however, the courts have shown little sympathy for such arrogance, and most States and the United States government have enacted what are called "tort claims" acts, acts that allow an individual to sue the government under certain limited circumstances.

"Tort claims" statutes vary dramatically from State to State and from State to Federal versions. However, all EMT's should understand two basic concepts of governmental immunity. First, an individual's right to sue a government, whether local, State, or Federal, may be substantially limited, depending on State law. Second, governmental immunity may or may not apply to any employee of that government. If it does apply, the personal responsibility for a government employee in damages sustained by a plaintiff will generally be less.

## GOOD SAMARITAN LEGISLATION

Starting in the early 1960's, a number of States have enacted statutes that are designed to provide freedom from liability to individuals who stopped and helped at the scene of an emergency. However, many EMT's do not understand good Samaritan legislation clearly. While the statutes vary from State to State, as a rule the good Samaritan immunity only applies when the EMT is acting in an emergency and in good faith, and is not guilty of any gross negligence or malicious misconduct toward the patient.

The intention behind the good Samaritan statutes is laudable, but the results have not been. For example, the original good Samaritan concept was designed to provide a broad-based immunity to the well-intentioned nonprofessional bystander. Thus, many States have denied good Samaritan immunity to individuals who receive compensation for their services—doctors and EMT's. Worse, many acknowledged experts in prehospital emergency care have stated that the good Samaritan legislation has encouraged incompetent situations, thus actually making the good Samaritan statues detrimental to both patient and EMT. The good Samaritan statues are subject to serious constitutional questions that may (and in the judgement of some expert observers, ultimately will) result in their being declared unenforceable and unconstitutional.

Finally, the good Samaritan legislation only protects EMT's if they acted in good faith and without gross negligence or willful misconduct. Accordingly, it is easy to sidestep any good Samaritan legislation—all one has to do is allege that the EMT was negligent or malicious or did not act in good faith.

Most legal experts in prehospital care believe that the main effect of the good Samaritan legislation has been to create a false sense of security in the minds of most health care professionals. You as an EMT should be aware of how easy this legislation is to get around, and should not look on it as a substitute for competence or personal liability protection.

## LIABILITY INSURANCE

Liability insurance consists of a contract between the EMT and the insurance company. The contract provides that, in consideration of the EMT's payment of a specified premium, the insurance company will defend the EMT in the event of a lawsuit, subject to the terms and conditions of the policy, and will pay any judgment against the EMT up to and including the maximum limits provided by the policy.

In buying liability insurance, it is very important that you understand the terms and conditions of coverage, particularly the exclusions and limitations. You should also know that liability insurance ordinarily protects you not only from a money judgment, but also provides payment for legal fees, court costs, investigation and discovery expenses, and the cost of litigation generally. Knowledgeable observers have estimated that defending the average prehospital health care claim may run as high as $30,000 to $40,000, depending on where the case is tried. Finally, liability insurance provides you and your family with some assurance that financial disaster will be avoided in the event of unavoidable negligence.

Some health care professionals, notably physicians, advocate "going bare"—they claim that liability insurance is merely an incentive for claims-minded lawyers to sue. There is no statistical support for this belief. On the contrary, in almost every instance where an EMT who is "bare" has been sued, there has been serious financial deprivation from legal costs if not outright financial disaster. In our contemporary society there is no effective alternative to having adequate liability coverage.

## CLAIMS PREVENTION

The elements of conducting oneself so as to prevent civil suits from being brought in the first place include meticulous medical records, continuing education, and wholly professional demeanor—which includes a completely professional attitude.

## GOOD MEDICAL RECORDS

Much has been written about the necessity for complete, well-documented patient records. Accurate, thorough records help the EMS system's management, evaluation, and improvement and are integral to fighting disease and lowering accident rates; they are also necessary historical documents in any legal undertaking. For legal purposes, medical records should be complete, accurate, and legible; free of extraneous material; and kept so as to safeguard confidentiality.

### CONTINUING EDUCATION

By far the best way to prevent claims is to preclude them through competence. Assuming that EMT's have been adequately educated so that their training is at the level requisite to effective functioning in the field, such training and academic knowledge must be maintained throughout the scope of practice. Accordingly, you as an EMT should attend continuing education programs that emphasize not only your academic skills, but also your medical skills—your proficiency in the field. Keep up your professional reading so that you stay abreast of the latest information and developments in the field.

### DEMEANOR

The term "demeanor" encompasses your physical and personal appearance as well as the overall impression you convey to the public or your patients. Numerous statistical studies have shown that if an EMT is neat and well-groomed—whether uniformed or not—it promotes in a patient's mind the belief that the EMT is neat, competent, and professional. Conversely, a slovenly or unkempt appearance leads to doubts in the patient about the EMT's competence.

The first impression that the patient or the patient's family forms of the EMT may be a lasting impression when it comes to health liability claims. It is difficult to estimate how many claims have originated simply because the patient's family formed an incorrect impression of the EMT's ability because the EMT was unkempt. The value of cleanliness of person, equipment, and vehicle cannot be overemphasized: High health care standards depend on cleanliness and sanitation. Accordingly, take a great deal of care that not only you yourself, but also your vehicle, its passenger area, and the treatment area of all the equipment are clean and presentable for public inspection at all times.

### ATTITUDE

Much has been written recently about a phenomenon called "burnout," a condition to which public servants like teachers, fire fighters, and particularly health care professionals are peculiarly susceptible. While a long discussion of burnout is beyond the scope of this unit, it is important to note here that the EMT's attitude is perhaps the single greatest determining factor in claims prevention. If you are hostile, belligerent, or sarcastic toward your patients or their families, you will get hostility, belligerence, and sarcasm back from them. This both affects the quality of care you give the patient and increases the likelihood that the family will be so dissatisfied with that care that they seek punitive legal action.

Conversely, if you are kind, positive, and professional, it will make your job all that much easier—it will be easier to treat the patient, it will promote communication with the family, and it offers the greatest single assurance that you will not be viewed as an enemy if something untoward happens in the case.

It is undoubtedly true that thousands of health care liability claims have been precipitated because the patient or the patient's family viewed the EMT as being indifferent or hostile. A positive and professional approach will help you avoid this problem.

## Counseling and Therapy

Physically, psychologically, and emotionally, the delivery of emergency health care is one of the most demanding of all professions. EMT's work odd hours under adverse conditions, in inclement weather, and in an unstable field environment. To add to your problems as an EMT, you will see all stages and degrees of human suffering and degradation; you will frequently deal with death and human tragedy. Thus, it is important that you have a source of referral for counseling in order that you can understand and deal with your feelings effectively. Grief, anger, frustration, and even depression are normal human responses—but you need to be able to discuss them with a competent, professional coworker. Never let either yourself or your family become so isolated from counseling that you lose the ability to deal effectively with the feelings that the stress of your job stirs up. Only when you and your family are effectively integrated into a counseling environment that lets you discuss your problems openly will you be able to maintain your emotional stability and professional confidence.

### EDITORIAL NOTE:

The Department feels that the EMTs professional credibility and stature would be greatly enhanced through their individual identity with professional associations such as the National Registry of EMTs and National Association of EMTs which are in turn represented on the EMS Commission of the American Medical Association.

## Glossary

### Medical Control Definitions

**Algorithms:** Protocols in the form of decision trees or branching logic diagrams.

**Associate Hospital:** A hospital other than the central control hospital, within the same EMS system (Region area etc.) which may, upon request or by pre-arrangement, provide medical direction for field personnel.

**Central Control Hospital:** A major definitive care hospital having primary responsibility for providing online medical direction for field personnel serving the EMS system (Region, area etc.)

**Centralized Medical Control:** Descriptive of a system in which all medical direction is provided by the central control hospital. This hospital may or may not receive the patients for whom medical direction has been provided.

**Decentralized Medical Control:** Descriptive of a system in which medical direction is provided by more than one hospital in a region. An associate hospital providing medical direction may do so by referral or relay from the central control hospital.

**Field Personnel:** Those responsible for the treatment of medical emergencies at the scene and/or during transport.

Emergency Medical Technicians-Ambulance (EMT-As): Field personnel completed the 81-hour EMT-A course, or its equivalent.

Advanced EMTs (EMT-AAs): Those who have completed the 81-hour EMT-A course plus specified modules of the DOT paramedic course.

Paramedics (EMT-Ps): Those who have completed the full DOT paramedic course.

**Medical Direction:** Physician direction of life support procedures performed by paramedics, advanced EMTs, or EMT-As in the field.

On-line Medical Direction: Medical direction, via radio or telephone, of field personnel.

Off-line Medical Direction: Medical direction of field personnel through use of protocols, system design, case review, follow-up, training, etc.

**Protocols:** Written procedures for diagnosis, triage, treatment, transport, or transfer of specified emergency medical cases. These procedures are part of the official policy of the system and are reviewed and approved by representatives of the medical community.

**Medical Director:** The physician responsible for ensuring the quality of medical care throughout an EMS system. System consist of States, Regions, areas etc.

**Standing Orders:** Instructions, reviewed and approved by representatives of the medical community, directing field personnel to perform specified life support measures before, or in the absence of, establishing radio or telephone communication with a medical direction physician. These may serve as guidelines for the use of the protocols with or without medical direction.

## Selected Legal Terms

**abandonment:** The unilateral termination of a physician-patient relationship by the physician without the patient's consent and without the physician's making arrangements for appropriate follow-up care.

**affidavit:** A sworn statement that is usually written.

**affirmative defense:** Used in an answer to a complaint to plead facts that do not deny the behavior alleged but rather attempt to excuse it. Pleading good samaritan immunity, for example, is an affirmative defense.

**agency:** A relationship between parties in which one authorizes the other to act on his behalf and to exercise an element of personal discretion.

**assault:** The act of placing another in well-founded fear and apprehension of immediate bodily harm or battery without consent.

**battery:** The intentional and unauthorized touching of a person without his consent. For example, taking a blood sample without first obtaining the patient's consent may constitute a battery.

**causation:** The existance of some reasonable connection between the act or omission of the defendant and the injury suffered by the plaintiff. In a suit for negligence, the issue of causation requires proof that the plaintiff's harm resulted directly from the negligence of the defendant.

**contribution:** When two or more persons are equally liable for the plaintiff's injury and one has paid the judgment, contribution is the demand that the remaining persons who are liable contribute their share of the judgment.

**deposition:** An oral, sworn statement taken in preparation for trial in which a witness is asked questions and cross-examined. The questions and answers are stenographically transcribed.

**duty:** An obligation created either voluntarily, by statute, or by contract, the proper performance of which results in the creation of appropriate rights on behalf of the performing party.

**emergency doctrine:** A form of implied consent to medical treatment. When a person's life or limb is in imminent danger and the person is unable to consent to treatment, the law implies consent to emergency treatment and assumes that the person would consent if otherwise able.

**expert witness:** One who testifies at a hearing or trial, usually for a fee, and who has knowledge about the subject matter at hand that is beyond the average person's knowledge. In malpractice actions, physicians are often called as expert witnesses to explain such subjects as medical diagnosis and treatment.

**incompetency:** The inability of a person to manage his own affairs because of mental or physical infirmities. Often a guardian will be appointed to manage the person's affairs.

**informed consent:** A patient's voluntary agreement to be treated after being told about the nature of his disease, the risks and benefits of the proposed treatment, alternative treatments, or the choice of no treatment at all.

**injury:** Damage done to an individual by violating his legal rights.

**joint and several liability:** Several persons who share the liability for the plaintiff's injury can be found liable individually or together.

**liability:** A finding in civil cases that the preponderance of the evidence shows that the defendant was responsible for the plaintiff's injuries.

**majority, age of:** The age at which a child is considered to have become an adult in the eyes of the law.

**malfeasance:** The performance of a wrongful or unlawful act. Before, abortions were legalized, performing one was an act of malfeasance.

**minority:** Not of legal age; beneath the age of majority; a child in the eyes of the law. Minors cannot usually consent to their own medical treatment unless they are emancipated, that is, substantially independent from their parents, supporting themselves, married, or otherwise on their own, or unless a statute provides otherwise.

**misfeasance:** The performance, in a harmful or injurious way, of an act that is lawful. Performing cardiopulmonary resuscitation in such a way that the patient's chest is crushed may constitute an act of misfeasance.

**negligence:** Professional action or inaction on the part of the health professional that does not meet the standard of ordinary care expected of similarly trained and prudent health practitioners and that results in injury to the patient.

**negligence per se:** A finding of negligence that is made by showing that a statute was violated. For example, if a nurse injures someone by acting beyond the scope of her license, this statutory violation may constitute negligence per se.

**nonfeasance:** The failure to perform a legally required duty.

**reasonable person:** A hypothetical person used as an objective standard against which a defendant's actions in a negligence suit will be judged. The question will be raised whether a reasonable person, under the same or similar circumstances, would have acted in the same way as the defendant.

**respondeat superior:** The Latin phrase meaning "let the master answer." Under this doctrine, the employer is liable for torts committed by his employees within the scope of their employment. For example, a hospital is liable for the negligent acts of a nurse it employs.

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## Module II.

# Human Systems and Patient Assessment

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## Module II.
# Human Systems and Patient Assessment

## Unit 1. Medical Terminology

Medicine, like other specialized fields, has its own terminology. Familiarity with medical terminology will help Emergency Medical Technicians-Paramedics (EMT–P's) understand reading material and classroom discussion as well as think more precisely about medical problems. Knowledge of medical terms will facilitate communication with doctors, nurses, and other emergency medical technicians and paramedics.

Medicine employs a large vocabulary, which can be learned by using the system of word building, that is, putting words together from their parts. Many hundreds of medical words can be built by learning a few basic parts that can be combined in a variety of ways. A complicated medical word will seem less difficult after the meanings of these fundamental parts have been analyzed.

Medical terms are often derived from Greek and Latin roots. These root words or key words are the foundation of a word. An example of a root word is "aden," which means pertaining to a gland. A root word followed by a vowel to facilitate pronunciation, as in "adeno," is known as a combining form, which is not a complete word. Adenocarcinoma (a malignant growth of glandlike cells) or adenoma (a tumor, usually benign, with a glandlike structure) are complete words.

When two or more root words, a root word and a combining form, or a combining form and a whole word are put together, the result is called a compound word. Examples of the first two combinations include chickenpox and erythrocyte (red blood cell), respectively. Thermometer, speedometer, and microscope are examples of the latter, whereby "thermo," "speedo," and "micro" are the combining forms and "scope" and "meter" are the words.

A prefix is a part of a word that precedes the root word and changes its meaning. It is usually a preposition or an adverb. The final vowel of the preposition is dropped when the word to which it is affixed begins with a vowel. "Dys" is a prefix meaning disordered, painful, or difficult. Dysrhythmia implies a disordered heart rhythm. "Neuro" (denoting nerve), another example of a prefix, combines with the term "algia" (pain) to form neuralgia, which refers to an aching along the course of a nerve.

A suffix, or word ending, is a part that follows the root word and adds to or changes its meaning. It follows the root word without insertion of a connective "o."

You must be able to use a medical dictionary, which besides having all the features of a standard dictionary—pronunciation, spelling, vocabulary, definitions, etymologies, etc.—imparts medical information quickly, accurately, and conveniently.

A glossary of common medical terms is supplied at the end of each module of this manual. You should become familiar with the terms.

The suffix "pnea" means breathing. Dyspnea is interpreted as difficulty in breathing. "Itis" refers to inflammation, as in neuritis, which means inflammation of a nerve. Another common suffix is "ology," or the science of. Cardiology is the science of the heart. Neurology is the science of the nerves and of the nervous system.

Knowledge of the common root words, prefixes, and suffixes will enable you to deduce the meanings of many medical terms and will increase your ability to communicate with other health professionals.

Some common root words, prefixes, and suffixes with which the paramedic should become familiar are listed below. Also listed are common medical abbreviations and symbols that will prove useful in your day-to-day duties.

## Unit 2. Human Systems (Anatomy and Physiology)

The study of living things can be divided into four parts: anatomy, physiology, biochemistry, and biophysics. Anatomy is the study of organism structure; physiology, the study of organism function. Biochemistry is the study of cell chemistry; biophysics, the study of the physical processes of living things.

### Cell Structure and Function

A cell consists of a nucleus and cytoplasm, which contains cytoplasmic organelles. A cell membrane, or plasma membrane, surrounds each cell. The cell nucleus contains the cell's genetic material in the form of deoxyribonucleic acid (DNA) and directs protein synthesis. The cytoplasm performs the work of the cell: energy production; syntheses of large proteins, carbohydrates, and liquids (fats); and other specialized functions. The plasma membrane controls entry to the cell.

The cell nucleus has two major functions. First, it provides duplicate copies of the cell's DNA, which are needed when the cell divides. Second, it produces messenger ribonucleic acid (RNA) from the DNA genetic code. This messenger RNA then travels to the cytoplasm, where it directs protein synthesis.

Within the cytoplasm are cytoplasmic organelles, including mitochondria, rough and smooth endoplasmic reticula, and the Golgi apparatus. The mitochondria are sausage-shaped structures that serve as the cell's powerhouses; here oxygen-requiring reactions in glucose breakdown occur, producing more energy than earlier reactions outside the mitochondria not requiring oxygen.

The rough endoplasmic reticulum is a protein synthesis factory. Messenger RNA from the nucleus attaches to groups of ribosomes (RNA-containing structures) on the rough endoplasmic reticulum and directs protein synthesis.

Lipids, including steroid hormones, are synthesized and detoxified on the smooth endoplasmic reticulum. The Golgi apparatus packages synthesized proteins for secretion.

Biochemically, the cell contains proteins, carbohydrates, lipids, and nucleic acids. Proteins are synthesized on the rough endoplasmic reticulum from amino acids and serve two major functions: catalytic and structural. Protein molecules known as enzymes bring about, or catalyze, most metabolic reactions in the cell. As catalysts, enzymes speed up biochemical reactions without being changed themselves. Metabolic reactions catalyzed by enzymes include catabolic (breaking down) and anabolic (building up) reactions to proteins, carbohydrates, lipids, and nucleic acids. Catabolic reactions produce the energy that is then used in anabolic reactions to build needed large molecules.

In addition to serving as enzyme catalysts, proteins, when combined with lipids, make up all cell membranes, including the plasma membrane, the nuclear membrane (surrounding the nucleus), the mitochondrial membranes, and the membranes of the rough endoplasmic reticulum, the smooth endoplasmic reticulum, and the Golgi apparatus. Protein molecules called actomyosin also form the contractile structure of muscle.

Two other major classes of biochemical molecules, carbohydrates and lipids, serve both as immediate energy sources and as energy storage forms. Lipids, in addition, serve as structural components of cell membranes and aid digestion by emulsifying fats in the intestine.

Nucleic acids, which are the fourth major class of biochemical molecules, include DNA and RNA. DNA, found in the chromosomes in the cell nucleus, contains the genetic code. Chromosomal DNA duplicates itself prior to cell division, so that each "daughter"cell will receive identical genetic material. RNA, which is needed for protein synthesis, is synthesized from DNA. RNA synthesized from DNA is of three types: Messenger RNA, ribosomal RNA, and transfer RNA. Messenger RNA contains the code for protein synthesis. Ribosomal RNA, located on the rough endoplasmic reticulum, provides a framework for protein synthesis. Amino acids are transferred to the growing protein chain on the ribosomes by transfer RNA.

Cells have eight major properties:

- **Absorption and utilization of food and other substances.** Absorption occurs either by diffusion or by active transport across the cell membrane. Diffusion moves molecules from an area of high concentration to an area of lower concentration and does not require energy. Active transport, in contrast, can transport molecules from areas of low concentration to areas of higher concentration, but requires energy. Molecules absorbed by diffusion or active transport are utilized either by being broken down to provide energy or being built into larger molecules needed by the cell.

- **Respiration.** Respiration consists of the absorption and incorporation of oxygen and the oxidation of food.
- **Secretion.** Specialized cells make and deliver useful products to either the neighboring cells or the blood stream (e.g., digestive enzymes and hormones).
- **Excretion.** Excretion is the removal of products from the body.
- **Irritability.** All cells are sensitive to mechanical, chemical, and electrical stimuli and light. Nerve cells, however, have become specialized to receive stimuli.
- **Conductivity.** Conduction is the passage of an excitatory wave along the cell membrane. Nerve cells have also become specialized for conduction.
- **Contractility.** Shortening of the cell in response to a stimulus is the property most highly developed in muscle cells.
- **Growth and reproduction.** Growth results from the synthesis of cell components. After cells reach a certain size, they reproduce by dividing. More specialized cells, such as nerve cells, lose the ability to divide. Loss of these cells, therefore, is permanent. But less specialized cells, such as skin cells, can be replaced because they retain the ability to reproduce by cell division.

## Tissues

Collections of cells of specific types having specific functions make up tissues. The four main types of tissues are:

- Epithelial tissue, which makes up all covering and lining membranes of the body and all glands.
- Connective tissue, which supports and connects other tissues.
- Nervous tissue, which is specialized to receive stimuli and conduct messages over long distances.
- Muscle tissue, which is specialized to contract in response to stimuli from nerves.

### EPITHELIAL TISSUE.

Epithelium makes up all covering and lining membranes of the body; the outer skin layer and innermost and outermost layers of the intestines are all epithelial tissue. Similarly, the airways within the lungs and the pleural cavity surrounding the lungs are both lines with epithelium.

Epithelium in different locations is modified to perform different functions. For example, skin has an epithelial layer that is many cells thick to protect it from wear and tear. Respiratory epithelium is also modified for protection, but instead of being many cells thick, it has a ciliated surface and secretes mucus. The mucus traps dusst and bacteria, which the cilia(vibrating fingerlike projections from the epithelial surface) then move upward to clear the airways.

Other epithelial surfaces are modified for absorption and excretion. For instance, the intestinal epithelium is a single cell layer that allows nutrient absorption. This cell layer is folded into villi, increasing the intestinal surface area. To further increase the absorptive surface, each cell forms microvilli, unmoving fingerlike projections from the cell surface.

The epithelial layers of the glomeruli and tubules of the kidney are modified to excrete body waste products. Kidney glomeruli filter daily about 170 liters (l) of fluid from the blood into the kidney tubules. The kidney tubules selectively absorb and excrete water, electrolytes, and nutrient molecules, constantly maintaining the body's fluid.

Another type of epithelial tissue makes up glands, the organs specialized for secretion, of which there are two groups: Exocrine glands, those with ducts, and endocrine glands, those without ducts. Exocrine glands secrete their products through ducts that lead away from their surfaces. Sweat glands, which secrete onto the skin's surface, and sebaceous glands, which secrete an oily substance known as sebum outward along the hair follicles, are exocrine glands.

Endocrine glands, in contrast, secrete into capillaries running through them. Most endocrine glands secrete hormones, which will be discussed later in this module. The islands of Langerhans in the pancreas, which secrete insulin, and the thyroid gland, which secretes thyroid hormones, are endocrine glands.

### CONNECTIVE TISSUE.

The second major type of tissue is connective tissue, which connects and supports other tissues. Connective tissue is divided into three types: Loose connective tissue, hematopoietic (blood-forming) connective tissue, and strong supportive connective tissue. Unlike other tissues, connective tissue contains non-living intercellular material in addition to cells.

Loose connective tissue lies under epithelial membranes and surrounds glands, nerves, and capillaries. In addition to connecting and supporting these structures, loose connective tissue store fat in its fat cells.

Blood cells and blood-forming tissues form hematopoietic connective tissue. Blood cells include erythrocytes (red cells) leukocytes and lymphocytes (white cells), and cell fragments called platelets. Erythrocytes, leukocytes, and platelets are formed in the bone marrow. Lymphocytes are formed in the special lymph tissues. Blood cells and blood-making tissues will be discussed in more detail when the circulatory system is considered.

The strong supportive connective tissue includes cartilage, bone, tendons, and ligaments. Cartilage consists mainly of intercellular substance, which contains small islands of cells and is composed of collagen, a type of protein, and mucopolysaccharide, a protein-carbohydrate compound. The collagen and mucopolysaccharide form a firm gel strong enough to bear weight. Cartilage is found on joint surfaces and also forms a support for the ears, nose, and upper respiratory passages. In addition, cartilage forms a framework for bone growth except for the bones of the skull and face.

Like cartilage, bone is composed mainly of intercellular substance with few cells. However, unlike the intercellular substance of the cartilage, the intercellular substance of the bone is calcified. This intercellular substance consists of collagen and calcium phosphate salts.

Bone supports the entire body and protects delicate organs, such as the brain, lungs, and heart. Bones also serve as levers for the muscles, enabling them to move the body.

Tendons and ligaments are additional divisions of strong supportive connective tissue. Tendons consist of parallel rows of collagen fibers, separated by rows of collagen-producing cells, the fibrocytes. Tendons attach skeletal muscles to cartilage or bone. Ligaments are similar to tendons, but connect bone to bone.

### MUSCLE.

The third major tissue type, muscle, is specialized for contraction. Muscle cells are long, thin cells that contain long, thin protein molecules, actin and myosin. The actin and myosin molecules are arranged in a special structure that allows them to shorten the muscle cell by sliding across each other.

Muscle tissue is divided into three types: skeletal or voluntary muscle, cardiac muscle, and smooth muscle. Skeletal muscle is attached to bones and moves the body at joints. Cardiac muscle is found in the heart. Smooth muscle forms the muscle in the walls of hollow organs and blood vessels. Therefore, smooth muscle is found in the digestive tract, bladder, and bronchioles, as well as in arteries and veins.

### NERVOUS TISSUE.

The final major tissue type, nervous tissue, has highly developed properties of irritability and conductivity. These properties result from the nerve cell's specialized structure. Each nerve cell includes a cell body and processes called nerve fibers. Dendrites are short, branching nerve fibers that receive stimuli and conduct impulses toward the nerve cell body. The axon is a single long fiber that conducts impulses away from the nerve cell body. Conduction of impulses between nerve cells occurs at the synapse, where the axon of one nerve cell meets the dendrite or cell body of another.

Axons may be myelinated, that is, covered with insulating myelin to speed conduction over long distances. Nerve fibers traveling long distances may also form groups with common origins and destinations. In the brain and spinal cord, nerve fiber groups are called tracts; in the peripheral nervous system, the groups are called nerves.

## Homeostasis

All cells and tissues in the body must work together to maintain homeostasis—a constant internal environment necessary to maintain life. For example, temperature, electrolyte concentration, pH, and carbon dioxide levels must all remain within the normal limits. These factors are kept within narrow limits by regulatory mechanisms. One such regulatory mechanism is that for temperature control.

The body's temperature must be closely regulated, since the rate of metabolic reactions increases as the temperature increases. Thus, at low temperatures, metabolic reactions take place too slowly. At high temperatures, metabolic reactions take place too rapidly—and the body may actually cook.

Normally, heat produced in metabolism is lost through the lungs and skin. When additional heat loss is needed, blood vessels near the surface of the skin dilate, or expand. This brings more blood to the cooler body surface, where heat can be passed off into the environment. This vasodilation produces the flushed appearance noticeable in a overheated person. In a cold environment, these blood vessels constrict instead, decreasing heat loss, and making the face look whiter and pinched.

To maintain the delicate internal balance, similar regulatory mechanisms control electrolyte concentration, pH, and oxygen and carbon dioxide content. These regulatory mechanisms come into play whenever an imbalance occurs and continue until the balance is restored.

## The Language of Anatomy

Anatomy, too, has its own special vocabulary defining the precise location and movement of structures. Some of the terms relating to general regions of the body with which the paramedic is already familiar are:

Head
Neck
Trunk
Thorax (chest) and abdomen
Extremities

Terms related to location are:

Anterior (ventral): Toward the front of the body.
Posterior (dorsal): Toward the back of the body.

Superior: Upper.
Inferior: Lower.
Superficial: Near the surface.
Deep: Remote from the surface.
Internal: Inside.
External: Outside.
Proximal: Part nearest (with reference to the heart).
Distal: Part furthest (with reference to the heart).
Medial: Toward the center of the body.
Lateral: Away from the center of the body; to the side.

Terms related to direction include:
Supine: Lying horizontal on the back, face upward.
Prone: Lying horizontal on the front, face down.
Abduction: A movement away from the body.
Adduction: A movement toward the body.
Flexion: The act of bending, or the condition of being bent.
Extension: The movement that brings the parts of a limb toward a straight condition.
Pronation: Turning the palm downward.
Supination: Turning the palm upward.
Rotation: Turning a part of the body about its long axis.
Circumduction: Motion forming a cone with a joint at the apex and the distal end of the extremity tracing a circle; this movement is possible at the shoulder and hip and consists of successively flexing, abducting, extending, and adducting the extremity.

## Body Scaffolding: The Skeleton

The skeletal system provides a framework for the body, giving it form and protecting and enclosing its vital organs, such as the brain, heart, and lungs. The skeletal system is composed of (1) bones, 206 in number, which form the hard framework of the body; (2) cartilage, which provides connecting and supporting structures; and (3) ligaments, which bind bones together.

Bones are formed of a protein matrix, enabling growth, and salts (primarily calcium phosphate salts), which gives bones their hard, unyielding character. Living cells within the matrix constantly remodel the structure of bone and play an important role in the healing of fractures. Other cells (the marrow) occupy the cavities within the bone and produce blood cells. Like other living tissues, bones have a blood supply and require oxygen.

Bones are classified according to their shape (long, short, flat, or irregular) or according to their embryonic origin (membranous or cartilaginous). Long bones are found in the extremities and include the humerus, radius, ulna, femur, tibia, fibula, and the phalanges. Short bones are found in the wrist and ankles and include carpal and tarsal bones. Flat bones include the ribs, scapula, and some skull bones. Irregular bones include the vertebrae, coccyx, and mandible.

Membranous bones grow from connective tissue membranes and include bones of the skull and face. All other bones grow from cartilage by a process known as enchondral ossification. Enchondral ossification produces a bone with the following parts: Diaphysis, epiphysis, endosteum, marrow cavity, articular cartilage, and periosteum.

The diaphysis is the shaft of the bone and forms a hollow cylinder containing a central marrow cavity. The epiphyses are the widened ends of the bone. During growth, the epiphyses are separated from the shaft by cartilage plates known as the epiphyseal plates. The widened part of the shaft immediately next to the epiphyseal plate is called the metaphysis and includes the growth zone and newly formed bone.

The endosteum is the membranous lining of the marrow cavity. The marrow cavity extends the length of the diaphysis and in an adult contains yellow fatty marrow. In the child, most marrow cavities contain marrow that produces red blood cells. In the adult, red marrow occurs only in the cranial bones, ribs, sternum, vertebral bodies, and proximal epiphyses of the femur and humerus.

Articular cartilage covers the surfaces of the epiphysis and allows smooth motion of the joint. Elsewhere, a dense fibrous membrane containing red-blood vessels—the periosteum—covers the bone. The periosteum is important for bone growth and nutrition and for bone repair after a fracture. Fractures in children heal more rapidly than fractures in adults, because in children the periosteum is thicker.

The framework provided by the skeleton permits an erect posture and gives the body its characteristic form. It is made up of the following parts:

The skull consists of 29 bones. The most important are the cranial bones (among them the frontal, occipital, temporal, and parietal), which enclose and protect the brain; the upper jaw, or maxilla; the lower jaw, or mandible; and the cheek bones, or zygomata. The mandible is attached to the skull by modified joints (temporomandibular joints) that permit the lower jaw to move.

The cranial bones are fused at articulations called sutures. In infancy, the bones of the cranium are not fully fused and the sutures are soft; but as the baby grows, the bones of the skull fuse firmly, rendering the skull a rigid box that permits no expansion. Thus if bleeding occurs within the adult skull, or if brain tissue swells, the increase in intracranial volume will increase intracranial pressure and damage brain tissue.

The spinal column serves as the main axis of the body, providing rigidity but permitting some degree of movement. It also serves as a protective case, enclosing the spinal cord and the roots of the spinal nerves. The spinal column includes 26 bones, called vertebrae. At the top of the spinal column rests the skull. The skull contains the brain, which gives off long nerve tracts that form the spinal cord.

Ribs articulate with the upper vertebrae to form the thorax; the pelvis articulates with the lower part of the spinal column, or sacrum, to form the pelvic girdle. The spine is divided into five sections:

- **Cervical spine.** Comprising the first seven vertebrae in the neck region, the cervical spine is mildly convex anteriorly (toward the back), but straightens when the neck is flexed.
- **Thoracic spine.** Consisting of 12 vertebrae in the upper back with which the 12 pairs of ribs articulate (join). The thoracic spine is concave anteriorly.
- **Lumbar spine.** Made up of five vertebrae in the lower back, the lumbar spine is convex anteriorly.
- **Sacrum.** The sacrum articulates with the pelvis at the sacroiliac joint, forming part of the pelvic girdle.
- **Coccyx (tail bone).** The sacrum and coccyx together are concave anteriorly.

Each vertebra consists of a body, or solid portion, and a vertebral arch, which surrounds the opening (foramen) through which the spinal cord passes. The vertebrae are separated from one another by intervertebral disks—flexible, elastic connections of cartilage that cushion the vertebrae and permit some motion in the spine.

The rib cage, or thorax, includes 12 pairs of ribs and the 12 thoracic vertebrae with which they articulate. It includes as well the breastbone (sternum), with which seven superior pairs of ribs articulate anteriorly through costal cartilages. The eighth, ninth, and tenth pairs of ribs are attached at their anterior ends to the cartilage above them by costal cartilages. The anterior ends of the eleventh and twelfth pairs of ribs are free—hence the designation "floating ribs."

The upper extremities are composed of the bones of the shoulder girdle, the arms, the forearms, and the hands. The shoulder girdle consists of the scapula and clavicle on each side. The shoulder blade, or scapula, is a flat, triangular bone. Its superior and lateral parts form the socket of the arm joint, where motion is free in all planes. The scapula floats freely on the upper posterior ribs because it is not attached to the ribs beneath it. Instead, muscles travel between the scapula and vertebral column, humerus, and anterior ribs. Because the scapula covers the ribs, rib fractures that lie beneath it may not be detected during a physical examination. The collarbone, or clavicle, is a slender bone shaped like an italic "f" or a very shallow "s" attached by ligaments at the medial end to the sternum and at the lateral end to the scapula.

The upper arm, or humerus, articulates proximally with the scapula and distally with the bones of the forearm—the radius and ulna—to form the hinged elbow joint.

The radius and ulna form the forearm. An extension of the ulna, called the olecranon process, forms part of the elbow joint; you can feel it behind the elbow protecting the movement. The ulna is narrow and is on the same side of the forearm (the ulnar side) as the little finger. The ulna serves as a pivot around which the radius turns to rotate the palm upward (supination) or downward (pronation).

The hand includes three groups of bones: the wrist bones (carpals), the hand bones (metacarpals), and the finger bones (phalanges). The many subtle motions permitted by the joints of the hands and wrist enable men and women to perform highly skilled tasks.

The back of the hand is referred to as the dorsum and the front, the palm; the thumb side of the hand and wrist is called the radial side (after the radius), and the little-finger side is called the ulnar side (after the ulna).

The lower extremities consist of bones of the pelvis, upper legs, lower legs, and feet. The hip bone, or pelvic girdle, is in reality three bones—the ischium, ilium, and pubis—fused together to form a bony ring. The two ilial bones articulate posteriorly with the sacrum. Anteriorly, the three bones unite at a socket-like depression, the acetabulum, which receives the head of the long leg bone, the femur.

The thigh bone, or femur, is a long, powerful bone articulating proximally in a ball-and-socket joint with the pelvis and distally in a condylar joint at the knee. The femur consists of a head, the ball-shaped part that fits into the acetabulum; a neck, which is about 3 inches long and is set at an angle; and a shaft. The femoral neck is a common site for fractures, especially in the elderly.

The lower leg consists of two bones, the tibia and fibula. The tibia, or shin bone, forms the inferior component of the knee joint, where it is shielded anteriorly by the kneecap, or patella. The tibia runs anteriorly down the leg and can be felt just beneath the skin of the lower leg. The much smaller fibula runs posteriorly. The fibula is not a component of the knee joint but does make up the lateral aspect of the ankle joint (lateral malleolus) in its distal articulation. The medial malleolus, or bony knob on the inner side of the ankle, is the end of the tibia. The foot, like the hand, is composed of three classes of bones: ankle bones (tarsals), foot bones (metatarsals), and toe bones (phalanges).

Wherever two bones come together, they articulate, or form a joint. Joints are of several types. They may be fibrous, like those between the skull bones, allowing little motion, or cartilaginous, like the disks between vertebrae, allowing slight motion. Joints may also permit free motion. In a synovial joint, the articular surfaces are covered with cartilage and surrounded by a fibrous capsule lined with the smooth, slippery synovial membrane. This produces the joint cavity, which contains lubricating synovial fluid.

Synovial joints include:

- The gliding joint, or arthrodia, which allows only short slipping or gliding motion (e.g., the joint between the carpal and tarsal bones of the wrist and ankle).
- The hinge joint or ginglymus, which allows only flexion and extension (e.g., the interphalangeal joints of the fingers).
- The ball-and-socket joint, or enarthrosis, which allows movement in many directions (e.g., the hip and shoulder joints).
- The pivot or trochoid joint, which allows only rotation around a long axis. An example of a pivot joint is the joint between the proximal radius and the ulna. As the hand is turned from palm up to palm down (pronated), the head of the radius rotates on the pivot formed by the ulna.
- The ellipsoidal joint, which allows movement along two axes, but against a single elliptical surface (e.g., the joint at the base of the index finger that abducts and adducts the finger in addition to flexing and extending it).
- The saddle joint, which allows flexion, extension, abduction, and adduction, but more freely than in the ellipsoid joint. In this type of joint, two saddle-shaped surfaces are at right angles to each other (e.g., the joint at the base of the thumb).
- The condylar joint, which allows mainly flexion and extension. The condylar joint has two articular surfaces, or condyles. In this joint, flexion and extension movements are combined with gliding and rolling movements and with rotation around a vertical axis (e.g., the knee joint).

Joint motion occurs through the contraction and relaxation of skeletal muscles, which cross joints and attach to bone. Thus, bones serve as levers that enable skeletal muscle to move body parts.

## Muscles

Muscles are specialized structures that contract when stimulated. By contracting and relaxing, muscles move the body or its parts. They are classified according to their structure and function: Skeletal (voluntary) muscle, cardiac muscle, and smooth (involuntary) muscle.

Skeletal muscles are also called voluntary muscles because their actions are largely under voluntary control—in other words, you decide how they move. Involuntary muscles, like the heart, operate without your having to think about them. Skeletal muscles include all muscles attached to the skeleton and the muscles of the tongue, soft palate, pharynx, upper esophagus, and eyes. Most skeletal muscles attach to bone through tendons. These tendons then cross joints and create a pulling force between two bones when the muscle contracts. The action that results from contraction of a muscle can be determined from the position of the two muscle ends (origin and insertion) and from the movement allowed by the joint.

For example, the biceps muscle originates on the scapula. Its tendon passes over the head of the humerus and joins the body of the biceps muscle. The distal end of the biceps muscle gives rise to a tendon that passes over the anterior surface of the elbow and inserts on the radius. Therefore, when the biceps muscle contracts, it flexes the elbow and supinates the forearm.

Other examples of voluntary muscles are the sternocleidomastoid muscle, pectoralis major and minor, triceps, and the gluteus muscle group. The sternocleidomastoid muscle originates from the superior sternum and medial clavicle and inserts on the mastoid process of the temporal bone (just behind the ear). Contraction of one sternocleidomastoid muscle, therefore, flexes the neck, tilting the head toward the shoulder of the same side and rotating it slightly. The pectoralis minor originates from the second to fifth ribs anteriorly and laterally and inserts on the scapula. This muscle, thus, pulls the shoulder down and forward. The pectoralis major muscle originates from the medial clavicle, sternum, and the costal cartilages of the true ribs. It then inserts onto the proximal humerus. The pectoralis major, therefore, flexes the upper arm, drawing it across the chest.

As mentioned earlier, the biceps muscle flexes and supinates the forearm. In contrast, the triceps extends the forearm because it originates on the scapula and posterior humerus and inserts on the olecranon process of the ulna.

Three muscles that move the thigh are the gluteus maximus, medius, and minimus. The gluteus maximus originates on the iliac crest and posterior ilium, sacrum, and coccyx and inserts on the femur just beyond the greater trochanter. (The greater trochanter is an irregular process that forms the lateral upper edge of the femoral shaft.) Therefore, this muscle extends the thigh and rotates it outward.

The gluteus medius and minimus both originate on the lateral ilium and insert on the greater trochanter of the femur. They abduct the thigh and keep the pelvis stable on the femur. The gluteus minimus originates lower on the ilium than the medius and rotates the thigh inward. In contrast, the medius rotates the thigh outward.

Two other important muscle groups perform opposing functions. The quadriceps femoris group flexes the thigh and extends the leg, while the hamstring group extends the thigh and flexes the leg.

The diaphragm, another important skeletal muscle, originates on the lower border of the rib cage and inserts on a central tendon. The diaphragm is pulled downward and flattened as it contracts, thus enlarging the thoracic cavity. Although the diaphragm is a voluntary muscle and breathing can be controlled, respiration takes place involuntarily under the direction of the central respiratory center in the brain.

Cardiac muscle is a specialized form of muscle found only in the heart. This muscle is innervated by the autonomic nervous system. Cardiac muscle initiates its own contractions—a property known as automaticity. Cardiac muscle will be described further in Module VI.

Smooth or involuntary, muscles make up the muscular layers of the internal organs and blood vessels and is found in the walls of the esophagus, stomach, intestines, trachea, bronchi, urinary bladder, and blood vessels. In addition, smooth muscle forms the pyloric sphincter of the stomach and the inner anal sphincter. (A sphincter is a doughnut-shaped muscle that surrounds a natural opening, which it can close by contracting.) Smooth muscle is called involuntary muscle because it contracts involuntarily at the direction of the autonomic nervous system. The autonomic nervous system, which directs both smooth and cardiac muscle, will be described later in this chapter and in Module VII.

Muscle contraction requires energy, which comes from glucose breakdown. Glucose breakdown produces adenosine triphosphate (ATP), a high-energy nucleic acid, which the cell uses as an energy source. Glucose is broken down in two phases. In the first phase, glycolysis, one molecule of glucose is converted into two molecules of pyruvate. Glycolysis does not require oxygen, but can produce only two high-energy ATP molecules per molecule of glucose.

In the second phase, pyruvate enters the Krebs cycle. (The Krebs cycle is also called the tricarboxylic acid (TCA) cycle or the citric acid cycle.) In the Krebs cycle, pyruvate is broken down into carbon dioxide and water. This requires oxygen and produces 18 molecules of ATP per molecule of pyruvate. Since each molecule of glucose forms two molecules of pyruvate, the Krebs cycle yields an additional 36 molecules of ATP for each molecule of glucose. This makes a total of 38 molecules of ATP formed per molecule of glucose. When a muscle contracts too rapidly for oxygen delivery to keep up, glucose breakdown stops before it reaches the Krebs cycle. Pyruvate is instead converted to lactic acid, in a reaction that produces no ATP. Lactic acid accumulates, and the cells and body fluids become more acidic (lower in pH). In addition, only two ATP molecules are formed per molecule of glucose in the glycolytic path; therefore, glucose breakdown supplies the cell with much less energy when oxygen is not available. When oxygen again becomes available, lactic acid is converted back to pyruvate, which enters the Krebs cycle to be broken down to carbon dioxide and water. This releases an additional 18 molecules of ATP per molecule of pyruvate.

Because oxygen is needed to break down the lactic acid that accumulates, the cells are said to develop an oxygen debt during vigorous activity. This debt must be repaid when muscular activity stops. For this reason, respiratory rate and depth increase during vigorous activity and remain elevated until the oxygen debt is repaid.

Muscle fatigue occurs when the energy supply to muscle is inadequate. This may result from excessive muscular activity, in which case recovery occurs at rest. But muscle fatigue may also result from a shortage of essential nutrients, electrolytes (such as sodium and calcium), or oxygen. For example, in anemia, the oxygen-carrying capacity of the blood is reduced. Therefore, the muscles receive less oxygen from the blood and fatigue more rapidly.

Only one-third of the energy produced during muscle contraction is used to perform work; the rest is liberated as heat, which helps to maintain body temperature. When the body is exposed to the cold, heat production can be increased through muscle activity. A person suffering from the cold may voluntarily walk or run or involuntarily shiver to increase heat production.

### MUSCLE DYSFUNCTION

Several factors may be responsible for muscle dysfunction. The muscle itself may be affected by injury, illness, or the lack of essential nutrients and oxygen. Muscle dysfunction may occur even in healthy, well-supplied muscle if the brain, spinal cord, or nerves supplying the muscle are damaged. In spinal cord injury, for example, the muscles supplied by the injured nerves no longer receive impulses and, as a result, do not contract. Similarly, motor centers of the brain damaged in stroke will not generate the impulses that signal the muscles to contract.

Skeletal muscles are profoundly affected by use and training. Muscles that remain unused grow smaller or atrophy; athletes' muscles grow larger and stronger during training.

## Body Cavities

Before considering the internal organs of the body, it is helpful to be familiar with the body cavities that house these organs: The skull and spinal column; the thoracic cavity, including two lateral cavities and the mediastinum; the abdominal cavity; and the pelvis.

The skull and spinal column contain the brain and spinal cord, respectively.

The thoracic cavity is divided into two lateral cavities and one medial cavity. The two lateral thoracic cavities occupy most of the thorax and contain the lungs. The mediastinum is in the midline, but extends more to the left than to the right. Mediastinal structures include the heart, which extends to the left of the midline; the aorta; the superior and inferior vena cava; the pulmonary arteries; the thoracic duct; the trachea; the esophagus; and the thymus gland.

The abdominal cavity is inferior to the thoracic cavity and is separated from it by the diaphragm, which attaches along the lower border of the rib cage. The abdominal cavity is lined with peritoneum (parietal, or wall, peritoneum). All the organs in the abdominal cavity are similarly covered with peritoneum (the visceral peritoneum). The area behind the posterior peritoneum is known as the retroperitoneum.

The abdomen is divided into four quadrants: Right upper, right lower, left upper, and left lower. The right upper quadrant contains the liver, the gallbladder, the ascending colon, and the right half of the transverse colon—all within the abdominal cavity. Retroperitoneally, this quadrant contains the head of the pancreas, most of the duodenum, the right kidney, and the right adrenal gland.

The right lower quadrant contains the cecum, the appendix, and the lower ascending colon. Contained within the left upper quadrant are the stomach, the spleen, part of the left lobe of the liver, the left transverse colon, and the upper descending colon. Retroperitoneally, the left upper quandrant includes the body and tail of the pancreas, the left kidney, the left adrenal gland, and a small part of the duodenum. The left lower quadrant contains the lower descending colon and the sigmoid colon.

Structures that are not located solely in one quadrant include the abdominal aorta, the inferior vena cava, and the jejunum and ileum—the second and third sections of the small intestine, respectively. The aorta and the inferior vena cava are located in the midline of the upper abdomen, retroperitoneally. The jejunum and ileum, which are suspended from the mesentery, a 6-inch-long, fan-shaped reflection of the posterior parietal peritoneum, move freely and are found in all quadrants of the abdominal cavity.

The pelvis is located below the inferior peritoneal lining of the abdominal cavity and houses the bladder, the rectum, and the reproductive organs. The inferior peritoneum forms a covering over the pelvic organs, which lie just below it and include the bladder, the rectum and in the female, the uterus, fallopian tubes, and the ovaries.

## Distribution: The Circulatory System

The circulatory system includes all the structures that transport body fluids and has two main divisions: The cardiovascular system and the lymphatic system. The cardiovascular system includes the heart and blood vessels. The lymphatic system includes lymphatic vessels and specialized lymphatic structures: The lymph nodes, the spleen, the thymus, and the tonsils.

### CARDIOVASCULAR SYSTEM.

The cardiovascular system transports blood throughout the body. The heart is a hollow, muscular organ that lies between the lungs and behind the sternum in the mediastinum. It is roughly the size of a clenched fist and is shaped like an inverted cone, with its base tilted to the right and its apex about 8 centimeters from the midsternal line. The heart consists of four chambers, two on the right and two on the left, and is actually a double pump.

The right side of the heart has two chambers—the right atrium and the right ventricle—and two valves. The right atrium collects blood from the veins of the body and delivers it to the right ventricle. The right ventricle then pumps blood to the lungs through the pulmonary arteries. The right ventricular wall is thicker than the right atrial wall because the right ventricle pumps against resistance of the pulmonary circulation. Two right heart valves allow blood flow only in the forward direction. The first, the tricuspid valve, lies between the right atrium and right ventricle and prevents backflow of blood into the atrium during ventricular contraction. The second, the pulmonary valve, prevents the blood in the pulmonary arteries from flowing back into the ventricle after contraction.

The left side of the heart also has an atrium, a ventricle, and two valves. The left atrium collects oxygenated blood from the pulmonary veins and delivers it to the left ventricle. The left ventricle then pumps blood through the aorta to the systemic circulation. Because it pumps against the largest resistance, that of the systemic or body circulation, the left ventricular wall is the thickest wall of the heart.

The left heart valves perform the same function as the right heart valves. The mitral valve, located between the left atrium and left ventricle, prevents backflow of blood into the left atrium during ventricular contraction. The aortic valve, lying between the left ventricle and aorta, prevents backflow into the left ventricle following ventricular contraction.

The heart receives its blood supply from the right and left coronary arteries, the first branch of the aorta. The left ventricle receives the largest share of the blood supply, because it pumps against the greatest resistance and, therefore, needs the most oxygen. The branches of the coronary arteries do not rejoin to provide detours should one branch become occluded. Therefore, occlusion of one coronary artery branch will lead to cell death in the area that branch supplies.

The heart has a conduction system to transmit the impulses that begin contraction in its different chambers. This conduction system begins in the sinoatrial node (SA or sinus node), which lies between the superior vena cava and the right atrium. Impulses from the sinoatrial node travel to both atria and to the atrioventricular node (AV node), which is located in the right lower interatrial septum. From the AV node, impulses travel down the atrioventricular bundle (bundle of His), which is located on the right interventricular septum and is about 1 centimeter long. The bundle of His then divides into the right and left bundle branches, which carry impulses to the ventricles.

The heart lies within a double-walled sac, the pericardium. Its inner layer, the visceral pericardium, is the outermost layer of the heart wall. The outer layer of the sac, the parietal pericardium, is composed of fibrous connective tissue. Between the two pericardial layers is a space containing a small amount of pericardial fluid. Pericardial fluid lubricates the pericardial sac to allow free movement of the heart during contraction and relaxation. The pericardial sac forms a potential space, which may fill with blood, fluid, or air. If the heart is traumatized, the pericardial sac becomes filled with blood, which restricts heart movement and decreases cardiac output, producing a condition known as pericardial tamponade.

Arteries are muscular tubes that conduct blood away from the heart. The largest artery of the body is the aorta, which arises from the left ventricle of the heart and carries oxygenated blood throughout the body. The major branches of the aorta in the thorax are the innominate artery, which branches to form the right subclavian artery and the right common carotid artery; the left common carotid artery, and the left subclavian artery. Major divisions of the abdominal aorta are the celiac trunk artery, the superior mesenteric artery, the renal arteries, the inferior mesenteric artery, and the common iliac arteries.

These arteries subdivide into smaller and smaller branches, eventually forming arterioles, which in turn form capillaries. Arterioles are the resistance vessels in the cardiovascular system. Vasoconstriction in arterioles produces large changes in their cross-sectional area and, therefore, in their resistance to blood flow. Vasoconstriction and vasodilation in arterioles regulate blood flow through capillaries. Capillaries are tiny, thin-walled vessels that do not contain smooth muscle in their walls. Their lumens are just large enough to allow red blood cells (erythrocytes) to pass single file. Capillaries deliver oxygen and nutrients to cells and remove carbon dioxide.

Blood from the capillaries enters the venules, which feed the veins that join to form larger veins. Like arteries, veins are hollow tubes containing smooth muscle in their walls, but vein walls are less muscular than arterial walls. Vasoconstriction in large veins does not appreciably alter their resistance, because it produces only small changes in their cross-sectional area. Constriction of large veins, however, does change the capacity or volume of the vascular system. Therefore, the large veins are considered capacitance vessels.

Blood returning from the lower extremities reaches the heart through the inferior vena cava; blood from the head, neck, shoulders, and upper extremities reaches the heart through the superior vena cava.

Blood returns to the heart through veins and is aided by skeletal muscle contraction, negative intrathoracic and positive intra-abdominal pressure during inspiration, and by valves, which prevent backflow.

Blood makes a double circuit in its journey through the body. The circulatory system can be viewed as two circuits with different functions. The first circuit, the pulmonary circulation, obtains oxygen from the lungs. Blood is pumped from the right ventricle to the pulmonary arteries and then into smaller and smaller arteries ending in pulmonary capillaries (where the blood is oxygenated). Finally, it is pumped into the veins, which carry the oxygenated blood back to the left atrium.

The second circuit, the systemic circuit, delivers oxygen and nutrients to the tissue. In addition to obtaining oxygen in the lungs, the blood picks up nutrient molecules from the liver. These nutrient molecules are transported from the liver to the right side of the heart, through the lungs, and back through the left side of the heart to the peripheral cells. The capillaries deliver oxygen, glucose, and other nutrients to the cells. The cells then metabolize the nutrients to carbon dioxide and other waste products, which are carried by the blood to the lungs and kidneys. Carbon dioxide is expired by the lungs, and the kidneys excrete other waste products.

At any time, a major proportion of the blood flow may be shunted into either of these circulations. In left heart failure with pulmonary edema, for example, a large volume of blood is present in the pulmonary circuit, engorging the pulmonary vessels and causing fluid to enter the airways. The resulting complex of symptoms of left heart failure are shortness of breath, coughing, and the discharge of foamy sputum.

The systemic circulation is divided into several smaller circuits. The upper extremities are supplied by branches of the axillary artery, which arises from the subclavian artery at the outer border of the first rib in the axilla (armpit). At the lower edge of the teres major muscle insertion into the humerus, the axillary artery becomes the brachial artery. The brachial artery travels anteriorly and medially down the arm and divides to form the radial and ulnar arteries 1 cm below the elbow bend. The radial artery travels down the radial side of the forearm (the thumb side); the ulnar artery travels down the ulnar side (the little-finger side). Branches of the radial and ulnar arteries supply the hands. Branches of the ulnar artery join branches of the radial artery in three arches within the hand: superficial palmar branch, deep palmar arch, and dorsal arch. These arches allow the radial artery to supply blood to the entire hand if the ulnar artery is occluded, and vice versa. Accompanying the arteries of the upper extremities are deep veins returning blood to the heart. These veins have the same names as the arteries, but for each artery there are two veins.

Superficial veins of the arm include the cephalic, basilic, and median cubital. The cephalic vein runs anteriorly and laterally in the forearm and upper arm. The basilic vein begins posteriorly and medially at the wrist, but curves anteriorly before reaching the elbow.

Shortly after passing the elbow, the basilic vein becomes deep. The medial cubital vein joins the cephalic and basilic veins in the elbow.

The head and neck are supplied by the common carotid and vertebral arteries. The common carotid arteries travel upward along the trachea and divide into the internal and external carotid arteries. The internal carotid arteries enter the cranial cavity, supplying the eyes and brain; the external carotid arteries supply the other areas of the head, including the neck, face, scalp, and outer coverings of the brain. Branches of the external carotid artery are connected to one another and to vertebral and internal carotid artery branches. These interconnections permit continuing blood flow should one branch become occluded.

Branches of the external carotid artery include the superior thyroid artery, the lingual artery, the facial artery, the occipital artery, the posterior auricular artery, the ascending pharyngeal artery, the superficial temporal artery, and the maxillary artery. The superior thyroid artery supplies neck muscles and the thyroid gland. Some neck muscles and parts of the tongue and mouth are supplied by the lingual artery. The facial artery supplies the face and neck. Neck muscles, the occipital area of the scalp, and the dura mater (a fibrous outer covering for the brain) are supplied by the occipital artery.

The posterior auricular artery supplies parts of the ear and the scalp behind and above the ear. The pharynx is partly supplied by the ascending pharyngeal artery. The superficial temporal artery supplies part of the face and the temporal area of the scalp. Parts of the ear, meninges (brain covering), face, scalp, and mouth are supplied by the maxillary artery.

Additional blood is supplied to the brain by the vertebral arteries. Each vertebral artery branches off the subclavian artery, passing through the transverse processes of the first six cervical vertebrae on its way upward to the cranial cavity.

Venous blood from the brain empties into venous sinuses. These are drained by the internal jugular veins, which travel along the common carotid arteries. The external jugular vein drains the areas supplied by the external carotid artery and is located superficially and laterally in the neck.

Blood supply to the thorax comes from the internal mammary (internal thoracic) arteries, the posterior intercostal arteries, the superior phrenic arteries, and the right and left bronchial arteries. The internal mammary arteries arise inferiorly from the subclavian arteries and descend behind the upper six coastal cartilages, 1 to 2 centimeters from the edge of the sternum. At each of the first six interspaces, each internal mammary artery gives off two anterior intercostal arteries. At the sixth interspace, the internal mammary arteries divide to form the superior epigastric arteries and the musculophrenic arteries, which supply the diaphragm.

The posterior intercostal arteries, which branch off the thoracic aorta, are paired with and joined to the anterior intercostal arteries. The superior phrenic arteries branch from the aorta as well and supply the posterior superior diaphragm. Additional branches of the thoracic aorta are the right and left bronchial arteries, which travel along the lung bronchi and supply them with oxygen.

The thorax is drained by the azygos vein, which travels anteriorly and to the right of the vertebral column and empties into the superior vena cava.

The abdominal wall receives its blood supply from the musculophrenic and superior epigastric arteries—branches of the internal mammary artery—and the inferior epigastric and deep circumflex iliac arteries—branches of the external iliac artery. The superior epigastric artery descends along the rectus abdominis muscle (medial anterior abdominal muscle, which originates on the pubic bone and inserts on the costal cartilages 5, 6, and 7). The inferior epigastric artery ascends along the rectus muscle. These two epigastric arteries connect to provide alternate sources of blood to the anterior abdominal wall.

Arteries supplying the digestive system include the celiac artery, which branches to form the left gastric, the splenic, and the common hepatic arteries; the superior mesenteric artery, and the inferior mesenteric artery. The left gastric artery supplies the lower esophagus and part of the stomach. The spleen and parts of the stomach and pancreas are supplied by the splenic artery. The common hepatic artery supplies the liver, gallbladder, and parts of the stomach, duodenum, and pancreas. Blood supply to the remainder of the small intestine and part of the large intestine comes from the superior mesenteric artery. The inferior mesenteric artery supplies the remainder of the large intestine and most of the rectum.

Blood from the stomach and intestines drains into the portal system, which carries the nutrient-rich blood to the liver. Blood from the liver empties into the hepatic veins, which lead into the inferior vena cava.

The terminal branches of the abdominal aorta arise at the fourth lumbar vertebra. These are the common iliac arteries, which branch to form the internal and external iliac arteries. The internal iliac arteries supply the pelvis; the external iliac arteries supply the lower extremities.

The external iliac artery becomes the femoral artery at a point halfway between the symphysis pubis and the anterior superior iliac spine, and directly below the inguinal ligament. Above the knee, the femoral artery passes posteriorly and becomes the popliteal artery. The popliteal artery branches below the knee to form anterior and posterior tibial arteries. The posterior tibial artery can be palpated behind the medial malleolus (ankle bone). The anterior tibial artery becomes superficial at the ankle and can be palpated on the dorsum of the foot as the dorsalis pedis pulse.

These arteries are accompanied by veins with the same or similar names. One important vein of the lower extremity, however, does not run along an artery: the greater saphenous vein arises superficially in front of the medial malleolus and travels medially and superficially up the leg to join the femoral vein near the origin of the femoral artery.

Each kidney is supplied by a renal artery, which branches from the abdominal aorta. One renal vein drains each kidney and empties into the inferior vena cava.

Blood pressure and pulse are frequently measured vital signs. Arterial blood pressure is the force with which blood pushes against the arterial wall. This force varies during the cardiac cycle of contraction and relaxation, producing the systolic and diastolic blood pressures. Systolic blood pressure is the highest pressure reached by the arteries as a result of left ventricular contraction; diastolic blood pressure is the lowest arterial pressure reached during relaxation, or diastole. Diastolic blood pressure measures total peripheral resistance to blood flow and reflects the amount of vasodilation or vasoconstriction in the peripheral blood vessels, particularly the primary resistance vessels—the small arteries and arterioles.

Mean blood pressure is the average blood pressure during diastole and systole. Mean pressure varies with both total peripheral resistance and cardiac output. Cardiac output is a measure of the effectiveness of left ventricular contraction and equals the stroke volume (the amount of blood ejected from the left ventricle during one contraction) times the heart rate.

The difference between diastolic and systolic pressures is the pulse pressure. Under normal conditions, the pulse pressure is a function of the stroke volume, or the amount of blood ejected by the left ventricle per contraction.

The strength of the arterial pulse, which is palpated over the artery, is also determined by the pulse pressure. Unlike arterial blood pressure, which is the force of blood against the arterial wall, the pulse represents a pressure wave started when the left ventricle ejects blood into the aorta. This pressure wave travels much faster than the blood, reaching the foot in two-tenths of a second. From the pulse, the left ventricular rate and rhythm can be determined; information about the stroke volume can also be obtained.

Blood pressure is regulated by cardiovascular centers in the brain. These centers receive information from pressure receptors located in the arch of the aorta and in the carotid sinus where the common carotid arteries branch into the internal and external carotid arteries. When blood pressure rises, pressure receptors send increased numbers of impulses to the cardiovascular centers, which inhibit sympathetic outflow and increase parasympathetic stimulation to the heart. Decreased sympathetic stimulation produces vasodilation in blood vessels; decreased sympathetic and increased parasympathetic stimulation to the heart decrease the rate and force of cardiac contraction. Therefore, the two major determinants of blood pressure, cardiac output and total peripheral resistance, both decrease, which leads to a lower blood pressure.

Conversely, when the blood pressure decreases, the pressure receptors send fewer impulses to the cardiovascular centers, which in turn decrease the parasympathetic stimulation to the heart and increase sympathetic stimulation. Hence the rate and force of cardiac contraction and the total peripheral resistance are increased, raising the blood pressure.

Blood is a fluid that fills the cardiovascular system. Blood contains erythrocytes (red blood cells), granular leukocytes and lymphocytes (white blood cells), and platelets suspended in plasma.

Erythrocytes contain hemoglobin, a red pigment that carries oxygen or carbon dioxide. Red blood cells are small cells that are concave on two sides. Because of this, all hemoglobin molecules are located fairly close to the cell surface, so that oxygen molecules do not have to diffuse far before reaching them.

Although plasma contains some dissolved oxygen, most oxygen in the blood is carried by hemoglobin. Therefore, blood low in hemoglobin-containing red blood cells carries less oxygen. Blood can be low in erythrocytes due to either anemia or hemorrhage.

White blood cells are the body's defense against bacteria and foreign materials. Granular leukocytes, such as neutrophils, ingest and destroy bacteria. In doing this, they themselves die and become pus. Lymphocytes are responsible for body immunity; they respond to bacteria and other agents that have previously infected the body and destroy them to prevent reinfection.

Platelets are small cell fragments that initiate blood clotting. Patients with low platelet numbers have problems with blood clotting and may bleed uncontrollably.

Additional factors involved in blood clotting are plasma proteins known as clotting factors. Like most other plasma proteins, most clotting factors are synthesized in the liver. Vitamin K is needed by the liver for the synthesis of clotting factors II (prothrombin), VII, IX, and X. Therefore, liver damage causing vitamin K deficiency may similarly cause uncontrollable bleeding.

In addition to clotting factors, plasma contains albumin and globulins. All plasma proteins contribute to blood viscosity, osmotic pressure, and volume. In addition, one type of globulins are antibody molecules, which serve as part of the immune system.

Plasma proteins retain fluid in the circulatory system by their effect on osmotic pressure. Osmotic pressure is a force that causes water to cross membranes from areas containing low particle concentrations to areas containing higher particle concentrations. Stated differently, water crosses membranes from areas of higher water concentration to areas of low water concentration due to osmotic pressure. If plasma protein concentration decreases, as in liver failure, plasma osmotic pressure also decreases and fluid leaves the blood vessels, causing edema in the tissues.

The average adult male has approximately 6 liters (6 quarts) of blood in his arteries and veins. When a person suddenly loses a significant amount of blood, as in trauma, hypovolemic shock may result. Hypovolemic shock is inadequate tissue perfusion with oxygenated blood due to lowered blood volume. Lowered blood volume is detected by baroreceptors (pressure receptors). These receptors send impulses to the brain, which produce compensatory changes in the cardiovascular system through the autonomic nervous system. Autonomic control of blood pressure is discussed further in Modules III, IV, and VI.

With a loss of 500 to 1,000 millimeters of blood, the skin becomes pale, cool, and moist, and urine output drops. The body attempts to compensate for hypovolemia by increasing the rate and force of the heart contraction, and thus increasing cardiac output. In addition, vasoconstriction occurs first in the skin and then in internal organs to shunt blood to the brain and heart.

Initially, vasoconstriction occurs in both precapillary arterioles and postcapillary venules. In addition to increasing peripheral resistance and thereby increasing blood pressure, this reduces hydrostatic pressure in the capillaries and allows them to absorb fluid from their surroundings. Absorbed fluid increases blood volume and can compensate for blood losses up to 1,000 milliliters.

With losses above 1,000 milliliters that are not replaced, lactic acid accumulates because of inadequate tissue oxygenation. The accumulated lactic acid causes relaxation of precapillary arterioles but not postcapillary venules; therefore, stagnant blood collects in the tissue, further lowering blood volume and leading to cell death due to lack of oxygen.

The lymphatic system consists of two parts: the lymph circulatory system and the special lymph tissues. The lymph circulatory system contains lymphatic capillaries, vessels, and ducts. Lymph is a watery, protein-containing fluid that forms from the fluid surrounding cells (the interstitial fluid). Lymphatic capillaries are microscopic blind-ended vessels that collect lymph from interstitial fluid. Notably, lymph capillaries are the only structures that can absorb protein from the interstitial fluid. Therefore, if lymph flow ceases, protein accumulates in the tissues. This increases tissue osmotic pressure and decreases plasma osmotic pressure. These two effects cause edema in the tissues.

Special lymphatic capillaries known as lacteals extend their blind ends into intestinal villae and absorb digested fats. Lymph in all lymphatic capillaries flows into lymphatic vessels, which empty into a main lymph channel, usually the thoracic duct. The thoracic duct then empties into the left subclavian vein. The right lymphatic duct, which drains into the right upper quadrant of the body, empties into the right subclavian vein.

The second part of the lymphatic system consists of special function tissues: Lymph nodes, spleen, thymus, and tonsils. Lymph nodes are small bean-shaped structures located along the course of lymphatic vessels. Lymph nodes filter lymph and ingest bacteria and other harmful substances like cancer cells and form lymphocytes and plama cells. Lymphatic tissue is a three-dimensional network of reticular fibers and cells. Occupying the meshes in varying degrees of density are lymphocytes.

The spleen lies in the left upper quadrant of the abdomen behind the stomach. Blood vessels—the splenic artery and vein—rather than lymphatic vessels, supply the spleen. Like the lymph nodes, the spleen destroys bacteria and forms lymphocytes and plasma cells. In addition, the spleen destroys wornout red blood cells and platelets.

The spleen is often ruptured during abdominal trauma, causing hidden blood loss. A ruptured spleen, therefore, may cause hypovolemic shock. When the spleen is injured, it may safely be removed by a surgeon because it is not a vital organ, although the long term effect of the absense of splenic function on the immune system and the body's response to infection is not well understood.

The thymus lies above the base of the heart and in front of the great vessels and trachea. Like other special lymph tissues, the thymus produces lymphocytes. However, unlike other lymph tissues, the thymus produces few plasma cells.

The tonsils form a ring of lymphatic tissue around the upper respiratory and digestive tracts. Tonsils are found in the upper pharynx and posterior lateral mouth. Tonsils do not receive afferent lymphatics, but do have efferent vessels that transport lymphocytes and plasma cells into the lymph stream. In addition to forming lymphocytes and plasma cells, the tonsils guard against bacterial infection of the upper respiratory and digestive tracts.

Lymphocytes produced by these special lymph tissues are of two kinds: T cells, or thymus-related cells, and B cells, or bursa-equivalent cells. T cells act as killer cells, which destroy foreign cells. B cells divide to form plasma cells, which produce antibodies. Antibodies form complexes with foreign cells or proteins to help the body destroy them.

## Respiration

### STRUCTURE.

Air enters the respiratory system through the nose and mouth. The nose has two parts: An outer part, which protrudes from the face, and the larger, inner part, which lies above the roof of the mouth. Each cavity of the inner nose is divided into three air passageways by three turbinates, which are bony projections from the lateral wall. Surrounding the inner nose and draining into it are four pairs of paranasal sinuses.

The nose filters, warms, and moistens the inspired air. This air then passes from the nose into the nasopharynx and from there into the oropharynx, or throat.

Both air and food pass through the oropharynx. Therefore, the opening to the larynx (air passage to the trachea) has a hingelike lid, the epiglottis, that closes over it during swallowing to prevent aspiration. Between the base of the tongue and the epiglottis are two depressions or valleculae, which are used as landmarks during endotracheal intubation.

Anterior to the esophagus, the larynx is a passageway to the trachea and houses the vocal cords. Air passes from the larynx into the trachea and through the right and left mainstem bronchi. The trachea begins in the neck and extends into the mediastinum; the adult trachea is about 11 centimeters long and 2-½ centimeters in diameter. The right mainstem bronchus is slightly larger and more vertical than the left mainstem bronchus; therefore, aspirated materials most often enter the right mainstem bronchus. Similarly, endotracheal tubes that are inserted too far tend to enter the right mainstem bronchus.

Each mainstem bronchus branches into secondary bronchi that enter the lungs. The lungs form cones that extend from slightly above the clavicles to the diaphragm and lie against the ribs anteriorly, laterally, and posteriorly. The lungs are separated by the mediastinal structures, including the heart and great vessels.

The lungs are covered by a smooth, moist epithelial layer, the visceral pleura. The cavities that house the lungs are likewise lined with pleura, the parietal pleura. A small amount of pleural fluid fills the pleural cavity—the potential space between the visceral and parietal pleura. This potential space may become an actual space should air, blood, or fluid enter, producing pneumothorax, hemothorax, or pleural effusion, respectively. Normally, the lungs touch the inner walls of the pleural cavities, leaving no space between them.

Each lung is divided into lobes served by secondary bronchi. The right lung has three lobes: The right upper lobe, the right middle lobe, and the right lower lobe. In contrast, the left lung has only two lobes: The left upper lobe and the left lower lobe.

The secondary bronchus serving each lobe divides into smaller bronchi and these bronchi divide into bronchioles. The bronchioles finally divide into alveolar ducts, which lead into alveolar sacs containing many alveoli. The alveolar walls contain capillaries. Oxygen and carbon dioxide exchange between these alveolar capillaries and the air in the alveolus.

Air enters the lungs through a bellowslike action of the lungs, diaphragm, and ribs. During inspiration, the diaphragm contracts, becoming flattened and lowered. The intercostal muscles (between the ribs) also contract, enlarging both front-to-back and side-to-side chest diameters and creating a negative pressure in the lungs. Air enters the lungs until the inside and outside pressures are equal. The diaphragm and intercostal muscles then relax, and the lungs elastically recoil—producing expiration.

In the normal adult, the respiratory rate is about 18 per minute; in infants and children the rate is higher, about 24 per minute. (One respiration consists of an inspiration and an expiration.) Respiration is carefully regulated. A respiratory center in the medulla regulates respiratory rate and depth and contains both an inspiratory center and an expiratory center.

Normal respiratory depth is controlled by the inspiratory center through the Hering-Breuer reflex. During inspiration the lungs stretch, stimulating lung stretch receptors. These stretch receptors send inhibitory messages to the inspiratory center along ascending nerve fibers in the vagus nerve. When the lungs are expanded to their normal depth, messages reaching the inspiratory center shut it off. Expiration then takes place passively as the inspiratory muscles relax.

The respiratory center also carefully regulates respiratory rate and depth to maintain arterial carbon dioxide pressure ($PCO_2$) within narrow limits. Normal arterial $PCO_2$ is about 40 mmHg (conventional millimeters of mercury). Higher levels stimulate central chemoreceptors located in the medulla and peripheral chemoreceptors located in the aorta and carotid bodies. The aortic chemoreceptors are near the arch of the aorta. The carotid bodies are located at the point where the common carotid artery branches into internal and external carotid arteries. The respiratory center responds to increased $PCO_2$ by increasing rate and depth of respiration. The respiratory center similarly increases respiratory rate and depth in response to arterial oxygen pressure ($PO_2$) levels below 60 mmHg. However, normal arterial PO2 levels are from 80 to 90 mmHg. Therefore, the respiratory center exerts a much finer control over $PCO_2$ levels than over PO2 levels.

## Digestive System

The digestive system includes all organs that mechanically or chemically act on ingested food to allow it to be absorbed and to transform it so that it can be used by body cells. This system consists of the mouth, salivary glands, esophagus, stomach, intestines, liver, gallbladder, and pancreas.

Digestion begins in the mouth, which mechanically grinds ingested food into small pieces. Here also, enzymes released by the salivary glands begin chemical breakdown of starches (large carbohydrate molecules). The mouth consists of the lips, cheeks, gums, teeth, and tongue. The roof of the mouth is formed by the hard palate anteriorly and the soft palate posteriorly.

From the mouth, food passes into the oropharynx, or throat, a tubular structure about 11 centimeters long that extends from the back of the mouth to the larynx and esophagus. As food is swallowed, the epiglottis closes over the laryngeal opening, permitting food to enter the esophagus but not the larynx and trachea. During swallowing, respiration is inhibited.

The muscles of the mouth, pharynx, and upper esophagus are skeletal. As expected, chewing (mastication) and the initial stages of swallowing (degluttion) are voluntary. However, after food enters the pharynx, subsequent movements are involuntary or reflex. This is, therefore, an exception to the rule that skeletal muscle is under voluntary control.

The esophagus is a collapsible, muscular tube extending from the inferior pharynx through the mediastinum to the stomach, a distance of 25 to 30 centimeter. When liquids are swallowed they pass through the esophagus by gravity. Solid foods, however, must be propelled down the esophagus by rhythmic contractions known as peristalsis. Most semimoist foods require about 6 seconds to travel down the esophagus to the stomach.

The entrance to the stomach is protected by the cardiac sphincter, a doughnut-shaped muscle that closes the stomach entrance when it contracts. the cardiac sphincter normally relaxes when the stomach is empty and contracts when the stomach is full to prevent reflux of stomach contents into the esophagus.

The stomach is located in the upper left quadrant of the abdomen. Food entering the stomach mixes with gastric juice, which contains acid and digestive enzymes (mainly pepsin, an enzyme that breaks down protein). Peristaltic movements of the stomach wall churn food together with the gastric juice to begin protein digestion.

After the stomach mixes the food and gastric juice, the pyloric or lower stomach sphincter relaxes, allowing food to enter the first part of the small intestines, the duodenum. Ordinarily, gastric emptying is complete within 3 to 4 hours after food ingestion, but factors such as trauma, pain, emotional upset, or certain drugs may delay gastric emptying for long periods.

The duodenum is a U-shaped retroperitoneal structure much of which is located to the right of the the first through fourth lumbar vertebrae (L1-L4). In the duodenum, the partially digested food is further broken down by enzymes secreted from the pancreas, which also secretes bicarbonate into the duodenum to neutralize acid from the stomach.

The pancreas is located retroperitoneally, to the right of the midline, its head nestled within the curve formed by the duodenum, and its body and tail extending to the left. In addition to secreting digestive enzymes and bicarbonate into the duodenum, the pancreas secretes the hormones insulin and glucagon into the bloodstream. Insulin lowers blood glucose by increasing glucose transport to the cells. Persons who are diabetic have low insulin levels and, therefore, have difficulty regulating their blood glucose levels. Glucagon acts as an anti-insulin hormone by increasing blood glucose.

Food in the duodenum is also joined by bile, which is produced by the liver and stored in the gallbladder. The liver is located in the right upper quadrant of the abdomen. Part of the left lobe of the liver extends across the midline to the left upper quadrant. The gallbladder is a small organ that stores bile. It is locked behind the liver and extends slightly below the inferior margin of the liver. In addition to forming bile, the liver metabolizes carbohydrates, fats, and proteins; detoxifies harmful chemicals; and synthesizes plasma proteins including clotting factors.

Peristaltic movements of the duodenum mix the food with digestive enzymes, bile, and bicarbonate and propel the mixture into the more distal parts of the small intestine, the jejunum and ileum. As food passes through the small intestine, amino acids, simple sugars, and fat molecules are absorbed through the intestinal walls into the blood and lymph. Amino acids are breakdown products of proteins; simple sugars result from breakdown of starches and compound sugars.

The inner surface of the small intestine is folded into circular folds to increase surface area and, therefore, aid absorption. Surface area is further increased by the folding of the intestinal epithelial layer into villi. The epithelial cells in each villus, in addition, have microscopic fingerlike nonmoving projections from their absorptive surfaces—the microvilli. As an additional aid to absorption, the epithelial layer of the small intestine is a single cell thick.

Each intestinal villus contains capillaries and a lacteal. The capillaries absorb amino acids, simple sugars, and small fat molecules. Larger fat molecules are absorbed by the lacteals, which are lymphatic capillaries. Food molecules picked up by the intestinal capillaries are transported to the liver through the portal vein to be further metabolized by the liver. Fat molecules picked up by the lacteals are transported into the thoracic duct and from there into the left subclavian vein.

Unabsorbed materials continue into the large intestine or colon, where water is absorbed. The large intestine consists of the following parts: The cecum, appendix, ascending colon, transverse colon, descending colon, and sigmoid colon. The cecum is a blind pouch located in the right lower quadrant below the junction of the ileum and the colon. The cecum ends in a long narrow tube, the appendix.

The ascending colon extends upwards from the junction of the ileum and the cecum toward the liver. Posterior to the lower right margin of the liver, the ascending colon turns to the left and becomes the transverse colon. When the transverse colon reaches the lower border of the spleen in the far left upper quadrant of the abdomen, it turns inferiorly to become the descending colon. The descending colon then descends to the pelvis, where it becomes the sigmoid colon. The sigmoid colon next curves toward the midline and enters the rectum at the third sacral vertebra (S3).

Material from the sigmoid colon enters the rectum and is then excreted through an external opening, the anus, as feces. Passage through the anal canal is controlled by internal and external anal sphincters.

Normally, bacteria inhabit the distal small intestine and the colon. These bacteria ferment residual proteins and carbohydrates to produce the acids and gases that give feces their characteristic odor.

## Urinary System

The urinary system produces and excretes urine, a fluid containing body waste products. This system includes the kidneys, ureters, bladder, and urethra. The following functions of the urinary system carefully regulate body fluid compositions:

- Elimination of toxic substances and waste products from the body.
- Salt and water balance.
- Acid-base balance.

The kidneys are paired organs lying in the retroperitoneum at about the level of the 12th thoracic to 2d lumbar vertebra (T11–L2). Each kidney has an outer layer, the cortex, and an inner layer, the medulla, and contains about 1-½ million nephrons. The nephron, the functional unit of the kidney, consists of a glomerulus surrounded by a Bowman's capsule and renal tubule. A glomerulus is a cluster of capillaries that is fed by an afferent arteriole and that drains into an efferent arteriole. Renal tubules join together to form collecting tubules, which collect urine for excretion through the ureters.

Water and small molecules filter out of the glomerular capillaries, which are extremely permeable. Approximately 175 liters of glomerular filtrate are formed each day and enter the renal tubules. In the renal tubules, most of this filtrate is reabsorbed. The renal tubule reabsorbs water, sodium, chloride, bicarbonate, glucose, and amino acids. The renal tubular cells also secrete substances from the blood into the tubule. Substances secreted include potassium, hydrogen ions, and some drugs.

Urea diffuses into the medullary capillaries surrounding the tubules. By a special countercurrent mechanism, the urea in the medulla allows urine concentration. Concentration of urine by the medulla enables the body to excrete its waste products in a small volume of water, thereby conserving water.

The two kidneys produce 1 to 1-½ liters of urine daily. This urine is highly concentrated. For example, the kidneys may concentrate urea over a hundredfold, and the total concentration of dissolved molecules in the urine may be fivefold higher than in the plasma.

Reabsorption and secretion of all molecules by the kidneys is carefully controlled to maintain blood levels within narrow limits. Two hormones that control urine composition to maintain constant body fluid composition are ADH (antidiuretic hormone) and aldosterone. The ADH is secreted by the posterior pituitary when plasma osmotic pressure increases; it causes the kidneys to conserve water. Aldosterone is produced by the adrenal cortex when the plasma sodium level, blood volume, or blood pressure decrease. Aldosterone increases sodium uptake and potassium excretion by the kidney tubules. Increased sodium reabsorption directly affects the tubule, leading to water retention. This then leads to ADH secretion and additional water retention.

If the kidneys are damaged or otherwise unable to function, waste products are no longer effectively removed from the bloodstream but instead accumulate, sometimes to toxic levels. Adequate kidney function is critically dependent on the blood flow to the kidneys; therefore, in states of poor perfusion (shock), kidney function may be seriously impaired.

Urine from the collecting tubules empties into the ureters, which are tubes leading to the bladder. The urinary bladder, in turn, empties to the outside of the body through another excretory passage, the urethra. In the male, the urethra passes through the penis; in the female it opens in front of the vagina. The opening of the urethra to the exterior is called the urinary meatus.

As urine is continuously excreted by the kidneys, it accumulates in the bladder until about 300 milliliters collects. This distends the bladder and stimulates sensory receptors in the bladder wall, producing a desire to urinate. Under appropriate circumstances, the brain sends signals to motor nerves in the bladder, causing relaxation of bladder sphincters and bladder wall contraction. As a result, urine is discharged through the urethra in a process known as urination or micturition.

## The Reproductive System

The reproductive system includes all organs necessary for the creation of new members of the species and for the production of male or female hormones. In the male, the reproductive system consists of the testes, a duct system, accessory glands including the seminal vesicle and the prostate, and the penis.

The testes are the primary organs of reproduction in the male and lie outside the body cavity in a sac called the scrotum. The testes perform two major functions: Production of sperm in the seminiferous tubules and secretion of hormones by the interstitial cells.

The main hormone produced by the interstitial cells in the testes is testosterone, which stimulates protein synthesis and produces secondary male sexual characteristics. Stimulation of protein synthesis promotes skeletal muscle and bone growth. Secondary sexual characteristics promoted by testosterone include deepened voice, broadened shoulders, enlarged muscles, and a male hair distribution pattern.

The accessory glands of the male reproductive system are the seminal vesicles and the prostate gland. Seminal vesicles secrete a viscous fluid that contains nutrients needed for sperm metabolism. The prostate gland secretes a thin alkaline fluid that protects the sperm from acid present in the male urethra and female vagina. Sperm from the testes, viscous fluid from the seminal vesicles, and alkaline fluid from the prostate gland all enter a common duct system that leads to the penile urethra.

During sexual intercourse, the penis, through which the penile urethra passes, becomes engorged with blood to form a rigid erect copulatory organ. This occurs because the penis is composed of specialized cavernous tissue containing spaces. During sexual excitement, arteries supplying these spaces reflexly dilate, filling the spaces with blood.

During ejaculation, seminal fluid containing sperm is ejected from the penile urethra. Contractions of the seminal vesicles and prostate gland during ejaculation help eject the seminal fluid. Special mechanisms prevent urine from passing through the penile urethra during intercourse.

The female reproductive system includes the ovaries, fallopian tubes, uterus, vagina, external genitalia, and breasts. In addition to producing reproductive cells and female hormones, the female also nourishes the fetus during pregnancy in the uterus and nourishes the baby after pregnancy through milk production in the breasts. In addition, the female reproductive system delivers the baby from the uterus in a process known as labor and delivery.

The ovaries, which lie in the lateral pelvis, are functionally similar to the testes. Thus, the ovaries produce the reproductive cells, the ova or eggs, and estrogen and progesterone, the female hormones. However, unlike the testes, which produce about 100 million sperm per milliliter of semen, the ovaries produce only one ovum each month.

Each mature ovum is released from the ovary into the fallopian tubes, through which the ovum travels to the uterus. Fertilization (union of the ovum with a sperm cell) usually takes place during the ovum's journey from the ovary to the uterus; therefore, pregnancy usually begins in the fallopian tube.

The fallopian tubes are not directly attached to the ovaries, but open into the peritoneal cavity. This is significant because it allows infection of the female genital tract to ascend the tubes to the peritoneal cavity. In rare instances, it also allows pregnancy to occur in the abdominal cavity, rather than in the uterus. To help ensure that the ovum enters the fallopian tube and not the peritoneal cavity, the end of the tube is funnel shaped and fringed. From the fallopian tube, the ovum enters the uterus, a hollow muscular pelvic organ. The uterus, which is shaped like an inverted pear, is about 3 inches by 2 inches by 1 inch in the nonpregnancy state. During pregnancy, the smooth muscle cells of the uterus increase tenfold in length and many times in thickness. The uterus has two main parts: A body and a cervix, or neck, which extends into the vagina.

Each month before ovulation (release of an ovum from the ovary), the uterus prepares a special lining to nourish and cushion the potential embryo. If fertilization occurs, the fertilized egg implants in this special lining. If fertilization does not occur, this lining is cast off during menstruation. Menstrual flow usually lasts about 5 days. At its completion the uterus begins to develop a new lining in anticipation of the arrival of another egg from the ovary; thus, the cycle begins again.

The uterine cervix contains a narrow inner passage to the vagina. The vagina is a distensible canal leading to the external genitalia. It receives the male penis during intercourse and serves as a birth canal during delivery.

Female external genitalia include the vulva and clitoris. In addition to internal reproductive organs and external genitalia, the female reproductive system includes the breasts, which are located on the anterior chest wall. Breasts contain specialized secretory glands that produce milk to nourish the infant after delivery.

## Endocrine System

Body activities are controlled in two ways: (1) through electrical impulses conducted by the nervous system and (2) through chemical hormones secreted by endocrine glands and carried to target organs by the blood. Endocrine glands include the pituitary, thyroid, parathyroid, and adrenal glands; the pancreas; the testes; and the ovaries.

The pituitary gland, located near the base of the brain, actually contains two endocrine glands: The anterior and posterior pituitary glands. The anterior pituitary gland is the master gland of the body and regulates the function of most other endocrine glands. Five hormones secreted by this gland regulate other endocrine organs: Thyroid-stimulating hormone (TSH), adrenocorticotropic hormone (ACTH), follicle-stimulating hormone (FSH), luteinizing hormone (LH), and melanocyte-stimulating hormone (MSH). In addition, the anterior pituitary secretes two other hormones: Growth hormone and prolactin.

The hormones TSH, ACTH, FSH, LH, and MSH act on target organs to regulate their function: TSH increases secretion of thyroxine and triiodothyronine by the thyroid gland, ACTH stimulates the adrenal cortex to secrete glucocorticoids, and FSH promotes the development of ova and synthesis of estrogen in the female ovary. In the male, FSH promotes seminiferous tubule development and sperm production.

In the female, LH produces ovulation. In the male, LH is called interstitial cell stimulating hormone (ICSH) and stimulates testosterone synthesis. The final regulatory hormone produced by the anterior pituitary, MSH, produces increased skin pigmentation by stimulating pigment-producing cells in the skin. Two additional hormones produced by the anterior pituitary, growth hormone and prolactin, act directly on the tissues. Growth hormone increases protein synthesis needed for tissue growth and repair. It also promotes fat breakdown and increases blood glucose levels—an anti-insulin effect.

Prolactin acts on the female breast during and after pregnancy. During pregnancy, prolactin promotes breast development. After delivery, prolactin acts on the breast to initiate milk secretion.

The posterior pituitary is likewise an endocrine gland. This gland secretes ADH and oxytocin. The ADH acts on the kidney tubles to increase water reabsorption, thus producing a more concentrated urine and conserving water. Oxytocin stimulates uterine contractions during labor and delivery and stimulates milk ejection from the breast.

The thyroid gland is located in the neck, anterior to the trachea and just below the larynx. The thyroid gland secretes thyroid hormones and calcitonin. The thyroid hormones, thyroxine and triiodothyronine, increase the body's metabolic rate. Calcitonin decreases serum calcium levels.

The parathyroid glands are four small glands located on the posterior surface of the thyroid, which secrete parathormone. Parathormone increases serum calcium levels, opposing calcitonin, and increases potassium excretion by the kidneys.

The adrenal glands sit on top of the kidneys. Like the pituitary gland, each adrenal gland functions as a separate endocrine gland. The two functional divisions of the adrenal gland are the adrenal cortex and the adrenal medulla. The adrenal cortex secretes glucocorticoids, mineralcorticoids, and small amounts of sex hormones. Glucocorticoids include cortisol (also known as hydrocortisone) and corticosterone. These glucocorticoids promote normal protein, carbohydrate, and fat metabolism. During stress, glucocorticoids decrease lymphocyte numbers, decrease antibody production, and decrease production of fibroblasts, which are cells needed for wound healing. High glucocorticoid levels promote protein and fat breakdown, increase serum glucose levels, and thus counteract the effect of insulin.

In addition to producing glucocorticoids, the adrenal cortex produces mineralcorticoids—chiefly aldosterone. Aldosterone is produced in response to low serum sodium or low blood pressure and causes the kidneys to reabsorb sodium and excrete potassium.

The adrenal medulla produces epinephrine and norepinephrine, the "fight or flight" hormones. This gland, therefore, functions as part of the autonomic nervous system; its effects will be discussed in greater detail in Module IV.

The fifth endocrine organ, the pancreas, is located retroperitoneally adjacent to the duodenum on the right and extending to the spleen on the left. The pancreas secretes insulin, which decreases serum glucose by increasing glucose transport into cells. Insulin also increases cellular uptake of amino acids and fatty acids (breakdown products of fats). A second hormone secreted by the pancreas, glucagon, opposes insulin action by increasing blood glucose. It does this by increasing liver glycogen (a large storage form of glucose) breakdown. Thus, glucagon is a third anti-insulin hormone (the other two are growth hormone and glucocorticoid).

Two other pairs of endocrine glands are the testes and ovaries. As mentioned earlier, the testes secrete testosterone and the ovaries secrete estrogen and progesterone. Testosterone promotes protein synthesis and, therefore, growth. Testosterone also develops and maintains male secondary sexual characteristics—a deepened voice, broadened shoulders, enlarged muscles, and the male hair-distribution pattern which includes the beard, receding hairline at the temples, and a pubic hair distribution that is triangular with the apex upward.

Estrogen produced by the ovaries promotes monthly formation of the inner uterine lining. Estrogen also promotes breast development during adolescence and pregnancy. Sodium and water retention by the kidneys and protein synthesis are similarly promoted by estrogen. Like estrogen, progesterone aids monthly development of the inner uterine lining and causes sodium and water retention. Unlike estrogen, however, progesterone increases protein breakdown. Progesterone also acts on the female breast to promote secretory cell development.

Female secondary sexual characteristics develop partly due to estrogen and progesterone and partly because testosterone is absent. These characteristics include narrow shoulders, broad hips, a high-pitched voice, and female hair-distribution pattern. Women have less body hair than men, but more scalp hair. In addition, female pubic hair grows in a flat-topped distribution.

Control of body functions by the endocrine glands is carefully regulated. The anterior pituitary produces hormones that regulate endocrine target organs. Conversely, hormones produced by the target endocrine glands feed back on the hypothalamus, an area of the brain located above the pituitary. In response to the hormone levels that it senses, the hypothalamus adjusts its output of hormone-releasing factors, which it sends to the anterior pituitary. These hormone-releasing factors regulate anterior pituitary release of regulatory hormones TSH, ACTH, FSH, LH, and MSH. Thus, hormone production is finely controlled to maintain homeostasis.

## *Nervous System*

The nervous system functions as the body's master control system, continually gathering information about the internal and external environment and relaying appropriate directions to the muscles and glands. The nervous system is divided structurally into two parts: The central nervous system (CNS), including the brain and spinal cord, and the peripheral nervous system, containing the sensory (afferent) and motor (efferent) nerves.

The motor division of the peripheral nervous system can be functionally subdivided into a voluntary nervous system and an involuntary, or autonomic, nervous system. Voluntary motor nerves innervate (supply) most skeletal muscle; autonomic nerves innervate smooth muscle, cardiac muscle, and glands.

The brain directs the rest of the nervous system. It is divided into three major areas: The cerebrum, cerebellum, and brainstem. The cerebrum and cerebellum both contain gray and white matter layers. The gray matter layer, or cortex, consists of nerve cell bodies; the white matter contains myelinated nerve fibers.

The cerebrum is the uppermost area of the brain and is divided into two hemispheres by a deep medial longitudinal fissure. Each hemisphere is subdivided into lobes named for the overlying bones. Thus there are frontal, parietal, temporal, and occipital lobes.

Covering each hemisphere is a 2- to 4-millimeter-thick layer of gray matter, the cerebral cortex. The cell bodies making up the cerebral cortex form functional groups. The motor cortex, for example, occupies the most posterior area of the frontal lobe; the general sensory cortex is located directly behind the motor cortex, in the most anterior area of the parietal lobe; and the visual cortex is located in the occipital lobe.

The location of damage to the cortex can be determined from the resulting loss of function. For instance, blindness results when the occipital cortex is damaged, since this area contains the visual functions.

A second major area of the brain, the cerebellum, is located in the posterior inferior brain, below the occipital lobe of the cerebrum. Like the cerebrum, the cerebellum has an outer cortex containing nerve cell bodies. The cerebellum coordinates muscle activity and maintains posture and equilibrium.

The third major area of the brain is the brainstem, which is located below the cerebrum and behind the cerebellum. The brainstem includes the diencephalon, midbrain, pons, and medulla. The diencephalon lies below the center of the cerebrum and above the midbrain and includes the thalamus and hypothalamus. The midbrain is a short segment below the diencephalon and above the pons. The pons is a large, oblong-shaped area below the midbrain, in front of the cerebellum and above the medulla. The medulla is a 2-½-centimeter segment that joins the brainstem to the spinal cord.

The brain has eight major functions:

- **Sensation.** The brain receives sensory input from all sense organs, including the eyes, ears, nose, and taste buds, and from all receptors for pain, pressure, and temperature. This sensory input is then interpreted by the cerebral cortex.
- **Voluntary movement.** The cerebral cortex directs and assists voluntary movement by coordinating muscle actions and maintaining posture and equilibrium.
- **Mental functions.** Mental functions include memory, foresight, personality, speech, and intelligence, and are functions of the cerebral cortex.
- **Emotions.** Happiness, sadness, rage, and other emotions are functions of the thalamus (a subdivision of the diencephalon) and the cerebral cortex.
- **Control of autonomic functions.** The hypothalamus (a second division of the diencephalon) directs the autonomic nervous system, which innervates smooth muscle, cardiac muscle, and glands.
- **Control of endocrine function.** The hypothalamus triggers anterior pituitary secretion, which regu-

lates the hormone production of target endocrine glands.

- **Consciousness.** The reticular activating system, which originates in the brainstem and travels to the cerebral cortex, maintains wakefulness. Injuries or drugs that affect the reticular activating system produce unconsciousness.
- **Control of vegetative functions.** The medulla, which is part of the brainstem, controls respiration, heart rate, and blood pressure. Therefore, injury to the medulla can produce cardiorespiratory arrest.

The brain occupies the entire space within the skull and is enclosed by three membranes, or meninges. The innermost membrane, the pia mater, is a thin, highly vascular membrane adjacent to the brain tissue. Outside the pia mater is a delicate layer called the arachnoid membrane, which in turn is wrapped by the tough, outermost layer, the dura mater. The potential space between the dura and the arachnoid membranes is called the subdural space. It can accumulate blood after head trauma, thus forming a subdural hematoma.

Bathing the brain and spinal cord is a clear, colorless fluid—the cerebrospinal fluid (CSF). CSF flows in the subarachnoid space and is produced in the ventricles, the fluid-filled spaces within the brain. From the ventricles, the CSF travels to the subarachnoid space, where it is absorbed into the cerebral veins. This fluid cushion protects the brain and spinal cord from mechanical injury and supplies nutrients.

The second part of the CNS, the spinal cord, lies within the vertebral canal. Unlike the cerebrum and cerebellum, the spinal cord has a gray matter core surrounded by white matter. The gray matter contains the reflex centers and cell bodies of nerve fibers in long ascending and descending tracts. The white matter contains long ascending (afferent) and descending (efferent) nerve tracts that connect the brain with the peripheral nerves. The spinal cord does not extend to the bottom of the vertebral canal, but ends at the lower edge of the first lumbar vertebra (L1). The meninges surrounding the spinal cord extend lower, allowing lumbar puncture below the spinal cord to obtain CSF. The proximity of the spinal cord to the bony walls of the vertebra, especially in the cervical and thoracic regions, make it particularly vulnerable to injury. Damage to the cord in this area is almost irreversible.

The spinal cord has two functions:

- It conducts afferent impulses from the peripheral sensory nerves to the brain and efferent impulses from the brain to the peripheral motor nerves.
- It acts as a reflex center, where incoming sensory fibers synapse with outgoing motor neurons. These synapses may be direct or involve interneurons, which connect the sensory and motor neurons. If interneurons are involved, they may travel up or down the spinal cord to connect motor and sensory nerves at different levels of the cord, producing intersegmental reflexes. Since reflexes take place within the cord without sending information to the cerebral cortex for interpretation, reflex action is more rapid than voluntary movement. The response to the stimulus is always the same, however, since it is determined by the reflex arc structure. Reflexes are purposeful (as illustrated by the reflex withdrawal of your hand when you accidentally touch a hot stove).

Since the spinal cord contains ascending and descending tracts, spinal cord injury affects the function of all nerves below the injury. An injury to the lumbar spine causes paralysis and loss of sensation in the legs; an injury to the cervical cord causes paralysis and loss of sensation in the arms as well as in the legs.

The peripheral nervous system includes 12 pairs of cranial nerves and 31 pairs of spinal nerves. Cranial and spinal nerves contain afferent (sensory) and efferent (motor) fibers. Motor nerves are further divided into voluntary and involuntary, or autonomic, nerves.

Twelve pairs of cranial nerves leave the brain and cranial cavity through small holes in the skull. Afferent fibers in these nerves transmit vision, hearing, taste, smell, and facial sensation. Efferent fibers control the eye muscles, the muscles involved in chewing and swallowing, and the smooth muscle of thoracic and abdominal regions.

Thirty-one pairs of spinal nerves exit from the spinal cord at the intervertebral openings. These nerves are named and numbered according to the adjacent vertebra: There are 1 coccygeal, 5 sacral, 5 lumbar, 12 thoracic, and 8 cervical spinal nerves. The spinal cord ends at the lower edge of the first lumbar vertebra (L1). For this reason, lumbar, sacral, and coccygeal nerves travel from the spinal cord through the vertebral canal to their intervertebral openings, forming the cauda equina. The spinal nerves contain afferent and efferent fibers to parts of the body not supplied by the cranial nerves.

The autonomic nervous system, a division of the peripheral motor nerves, includes both cranial and spinal nerves. The autonomic system is subdivided structurally and functionally into the parasympathetic and sympathetic nervous systems. The parasympathetic division arises from the cranial and sacral nerves; the sympathetic division arises from thoracic and lumbar nerves. Both innervate smooth muscle, cardiac muscle, and glands. The parasympathetic system, however, controls vegetative functions such as digestion and resting heart rate. Effects of the parasympathetic stimulation are specific.

In contrast, activation of the sympathetic nervous system during stress starts a widespread "fight or flight" response, resulting in increased heart rate, increased blood pressure, bronchial dilation, and decreased intestinal motility.

Many organs are innervated by both the parasympathetic and the sympathetic nervous systems. Such thorough and careful regulation is needed to maintain homeostasis. Since the autonomic nervous system is important in the regulation of internal organs and blood vessels and because many drugs mimic its effects, it will be discussed further in Module IV.

## Unit 3. Patient Assessment

You, the paramedic, must function as the eyes, ears, and hands of the physician, since the medical director can neither see, hear, nor feel patients in the field. To make appropriate decisions about patient care, the physician will depend totally on information you provide, based solely on your questions and observations. You are responsible for helping the physician obtain an accurate picture of the patient and the patient's symptoms. You are the physician's eyes and ears, gathering information, and the physician's hands, treating the patient. Obtaining a patient history, performing a physical examination, and communicating the collected information to the medical director are skills that you must master to perform effectively.

As you develop history-taking skills, remember that a haphazard presentation or one containing unnecessary information will not be helpful to the medical staff at the other end of the radio. Your initial radio communication should contain all the needed information in no more than 50 words and take less than a minute to be transmitted. To accomplish this, memorize a standard presentation form—the one shown in "Presenting Medical Information" is a workable example—and use it every time you transmit information. And after delivering your patient to the hospital and into the hands of the emergency department's personnel, listen to the tape of the run. You may pinpoint something that will help you improve your presentation.

The section that follows will help you develop the needed skills.

### Overall Approach

In the field, history-taking and physical examination have the following purposes:

- To win the patient's confidence and thereby relieve some of the anxiety due to discomfort.
- To rapidly identify the patient's problem(s) and establish which problem(s) require immediate care in the field.
- To obtain information about the patient that may not be readily available later in the hospital (e.g., observations about the environment in which the patient was found).

The information a paramedic gains through history-taking and physical examination will depend largely on the way in which these procedures are performed. Patient assessment must be unhurried and systematic; a hasty, shotgun approach always leads to omissions. Therefore, you must learn to take a history and perform a physical examination in a specific order so that no important information is missed. The depth and amount of information gathered and the questions asked are modified by the urgency of the patient's need for medical care to begin.

For teaching purposes, the method for obtaining a history will be presented first, followed by the method for physical examination. In the field, however, the order will be dictated by the circumstances.

Urgent treatment may be required before you can stop to ask questions or perform a thorough examination, as in the case of a patient with an obstructed airway. You may find it expedient to take a history while carrying out the physical examination. (Certainly communication with the patient should not lapse during the physical exam.) Circumstances will dictate when to interview, when to conduct a physical examination, and when to provide treatment. Judgment is required to make such decisions, and only experience will enable you to select the most appropriate approach in a given situation.

### Taking a History

History-taking begins as soon as you see the patient; before asking a single question, take measure of the patient's environment. If the patient is at home, what is its appearance? Is it clean and well maintained? Are there bottles of medication nearby that might give a clue to the patient's underlying illnesses? Do empty bottles or glasses give evidence of alcohol consumption? And if the patient is a victim of trauma, in what position was the patient found? Does the placement of the patient and any objects at the scene give a clue to the mechanisms of injury? Take note of certain characteristics of the patient—posture, dress, facial expression, and attitude. Is the patient in pain or discomfort? Is the patient frightened?

History-taking may involve the patient, the patient's family, and bystanders. In general, if the patient is able to communicate, it is best to question him or her rather than the others. The patient is thus reassured that he or she is the center of medical interest and still retains some control over the situation. If you need to question others, do so one at a time; it is difficult to derive a clear idea of what is going on from a chorus of voices. On some occasions, it is advisable to have a partner question a family member in another room while you interview the patient, especially if there are conflicting reports from the two sources.

Unlike interviewing in the hospital, where questioning can be lengthy and open-ended, interviewing in the field under emergency circumstances usually requires a more direct approach. Do not suggest answers to the patient; allow the patient to answer in his or her own words. Thus the patient should be asked "When does the pain come on?" and not "Does the pain come on after exertion?" Avoid asking questions that can be answered with a yes or no. To obtain pinpoint responses, you may provide the patient with alternatives. For example: "Does the pain stay in one place or does it move around?"

If the patient is being questioned during the administration of the physical examination, it is important that you ask questions about a given body area or organ system before examining it. If the first question about a given organ or system is asked during or after its examination, the patient may take this to mean that a significant abnormality has been found, and such an assumption creates anxiety.

When taking a history, the paramedic first needs to obtain the patient's chief complaint—the problem that prompted the call for help. Often, it will be obvious. Take, for example, the man who lies bleeding in the street after being struck by an automobile. In this case, the chief complaint is "struck by automobile." But even in this instance, despite the seemingly clear-cut circumstances, it is useful to determine what is bothering the patient most, for that report may lead to unexpected findings. The patient may have a dramatically evident compound fracture of the left leg, and yet his chief complaint may be, "I can't breathe." An examination may uncover an unsuspected tension pneumothorax.

Most chief complaints are characterized by pain, abnormal function, some change from a normal state, or an observation made by the patient. From this initial statement, the paramedic proceeds to develop a line of questioning to learn more about the chief complaint. This amplification of the chief complaint is called the history of the present illness.

The qualifying information that makes up the history of the present illness includes the following:

- **Location.** Where is the problem being experienced? If there is pain, does it radiate? Where? Under what circumstances?
- **Quality.** If pain is being experienced, what does it feel like? Dull? Sharp? Cutting? Throbbing? Crushing? If the problem is a limitation of function, such as difficulty in breathing, how is that experienced?
- **Intensity.** How bad is the pain? The patient's response will be a mixture of the actual degree of severity and the subjective reaction to pain. Thus, it is necessary to form an impression of the patient's temperament to interpret the description of pain.
- **Quantity.** How many? How often? How much? How big? Any of these may apply depending on the nature of the symptoms reported.
- **Chronology.** Time of onset, duration (for medical problems), frequency (for medical problems). If several symptoms are reported, what is their temporal relation to one another? Which came first?
- **Setting.** If the problem is trauma related, how did the injury take place? What precisely occurred? Were there any contributing physical causes (e.g., a syncopal episode (fainting) leading to a fall)? If dealing with a medical problem, under what circumstances did the symptom occur? Can the problem be related to the patient's activity or environment (e.g., chest pain experienced on exertion or on going out in the cold)?
- **Scenario of the first symptoms.** If treating a medical problem, where did the first symptoms occur? What was the patient doing at the time?
- **Aggravation and alleviation.** Does anything make the symptoms worse? Better?
- **Associated complaints.** Are there any clearly related symptoms, such as dizziness, sweating, etc.?
- **Modification of symptoms.** Has the patient taken any medications or made any other attempts to modify the symptoms? To help interpret the patient's description of symptoms caused by medical problems, it is useful to ask what the symptoms prevent the person from doing and whether they awaken the patient at night.

Take, for example, the middle-aged patient with classical symptoms of a myocardial infarction. The information elicited in the history of the present illness might be as follows:

Chief complaint: Chest pain

- Location: Substernal, radiating to the left arm.
- Quality: Crushing.
- Intensity: Very severe, feels as if the patient will die from it.
- Quantity: Had two such attacks today.
- Chronology: This attack started 2 hours ago and has persisted since. The patient has had several attacks in the past few days, but none this severe. This attack began with pain and was followed by profound weakness.
- Setting: The patient was sitting watching television when the pain came on; dinner had been eaten about 1 hour before.
- Scenario of the first symptoms: The first episode of chest pain occurred after strenuous exertion, but this attack occurred at rest.
- Aggravation or alleviation: Nothing seems to make it better.
- Associated complaints: Also feels nauseated, weak, and dizzy. Has been sweating profusely.

- Attempts to modify symptoms: Took two nitroglycerin tablets, but they did not help.

By exploring the chief complaint— chest pain—the paramedic develops a very precise concept of what has happened to the patient.

After completing questions about the present illness, obtain next any pertinent information about the patient's past medical history. In the field, primary interest is focused on those aspects of the patient's past medical history that relate to the current problem—either because they are directly related to the present problems or because they could adversely affect the outcome of the present problem. When treating a burn victim, for example, it is important to know whether there are underlying cardiac or respiratory problems that might impair breathing or influence the response to fluid infusions. It is not particularly relevant, on the other hand, to learn whether the patient had underwent a hernia operation 5 years earlier or had measles when a child. In general, you will want to determine the following:

- Does the patient have any major underlying medical problems (cardiac, respiratory, renal, etc.)? Is he or she a diabetic? Is the patient currently under a doctor's care for any serious condition?
- Does the patient take any medications regularly? If so, what are they? Medications may give important clues to a patient's underlying condition even when the patient may not be fully aware of the nature of the problem. Was the medication taken today? When? Were any other drugs or alcohol taken during the past several hours? If so, when? How much?
- Does the patient have known allergies? Ask specifically about Novocain (the "numbing medicine" used in the dentist's office), since you may be administering the related drug, lidocaine, to patients with certain arrhythmias (irregular heartbeat).
- Does the patient regularly see a particular doctor? At a particular hospital? In many instances, it is desirable to take the patient to the hospital where his or her medical records are on file, provided that the hospital is near and has the facilities necessary to deal with the patient's current problem.

Several mnemonic devices might be helpful in identifying the patient's problem and remembering the appropriate techniques. These include always taking a S-A-M-P-L-E history and P-A-I-N.

Symptoms
Allergies
Medications
Previous Illnesses
Last meal
Events prior to emergency

Period of pain (How long? What started it?)
Area
Intensity
Nullify (What stops it? Rest? Position? Medications?)

In the hospital setting, it is also customary to obtain a family history. This information is rarely of immediate use in the field and, therefore, usually not worth taking the time to elicit. The patient with a crushing chest pain will be treated as a possible myocardial infarction whether both his or her parents died in their forties of heart attacks or lived to an old age. The information volunteered about the family, however, may provide useful clues as to what is worrying the patient. The patient who states that his or her father died at the age of 40 of a heart attack is clearly concerned about suffering the same fate. It is worth pursuing this line of inquiry, if for no other reason than to let the patient ventilate any worries. You might then ask the patient, "Are you worried that the same thing will happen to you?" If the answer is yes, find out why that worry is prominent: Has the patient suffered any particular symptoms that have provoked this concern?

The current family history may provide useful information when you suspect that the patient is suffering from an infectious disease. If, for example, the chief complaint is vomiting and diarrhea, it is useful to know whether anyone else in the household has similar complaints.

When dealing with a trauma patient, the events leading up to the injury may be very important. First determine whether the type of injury was blunt or penetrating.

Blunt injuries transfer energy to the body in general without penetrating the skin. The amount of energy transferred determines the amount of injury. A punch thrown into the epigastric region may transfer 100 to 150 pounds of energy. In an automobile accident, the body continues to travel at the impact speed after the automobile stops. There may be as much as 5,000 pounds of force involved. Because the laws of physics dictate that energy can be neither created nor destroyed, this energy must be absorbed. It is absorbed in the bending, tearing, and deformation of body tissues. When confronted with blunt trauma then, it is important to identify the type of instrument that produced the injury and, if possible, to assess the amount of energy involved in the blow or, at least, the speed of impact.

If motor vehicular trauma has occurred, ascertain the direction of impact (frontal, side, rear, rotational, or rollover) in order to reconstruct, in your mind, the pathway traveled by the occupant of the motor vehicle. The parts of the body that struck the interior compartment of the automobile are most likely to have been injured. In this manner, you can anticipate the most likely severe injuries.

For example, a frontal collision could result in cardiac contusion, fractured ribs, pneumothorax, or decelerating aortic injury from the chest compression. Laceration, fractures, subsequent hemorrhage of intraabdominal organs, and cervical spine fractures associated with any facial injuries could also be anticipated. A posterior fracture dislocation of the hip, a common injury, occurs when the knee strikes the dash. The forward momentum of the torso, traveling in the direction of the shift of the femur, allows the head of the femur to project posteriorly. This injury is often associated with posterior fracture of the acetabulum producing a fracture dislocation.

A side impact collision could cause flail injuries to the lateral part of the chest and a pneumothorax. A fractured clavicle might result as the arm is driven inward and the scapular posteriorly. In the lower extremities, the head of the femur may be driven through the acetabulum.

Rear impact collisions are doubly complicated because the initial forces the head back over the seat. As the car comes to stop, the body moves forward and strikes the dash or the steering column, incurring injuries like those suffered in a frontal collision.

Because of the many directions that an unrestrained occupant can travel in a roll-over collision, the injury pattern is difficult to predict.

Similar thinking can predict the kinds of injuries that occur in a motorcycle collision. Whether the rider has been thrown free of the motorcycle or is trapped between the motorcycle and the object with which it collided will determine the types and extent of injuries suffered. Also of importance is whether or not the rider was wearing a helmet.

Penetrating trauma transfers energy to the body in the form of lacerated or torn tissue. In the thoracic region, hemorrhage and air leaks to either the inside or the outside must be high on the suspicion list. In the abdomen, blood loss is the prime danger. In the head, neurological damage may be of major consequence.

## Physical Examination

The physical examination is divided into four steps, which apply to either a medically or traumatically ill or injured patient:

- Primary survey.
- Resuscitation.
- Secondary survey.
- Definitive care.

Physical assessment begins with the primary survey:

A—Airway
B—Breathing
C—Circulation
H—Hemorrhage
N—Neurological status

The primary survey is the first step in the paramedic's assessment of the patient and always takes precedence over all other aspects of history-taking and physical examination. Many times the primary survey will be completed in short order: when, for example, you encounter the alert, communicative patient with medical problems. Other times, however, close examination will be required to accomplish the primary survey: when the patient you are treating, let's say, is unconscious or the victim of major trauma. If the primary survey elicits any positive findings, such as an obstructed airway or massive hemorrhage, you will need to attend immediately to those injuries before proceeding with the assessment of the patient.

Once completing the primary survey and attending to any problems it uncovered, take a closer look at the patient and make a systematic examination from head to toe, being watchful for less obvious injuries or signs that may give clues to underlying medical problems. This examination is called the secondary survey.

During the secondary survey, you will employ several examination techniques with which you are already familiar. From your practice in cardiopulmonary resuscitation, you should be familiar with the look-listen-feel routine:

- Inspection (Look). You must be able to see the area of the body you are examining. Expose the area being examined to the best light available, Look for colors, contours, and symmetry.
- Auscultation (Listen). Use a stethoscope. The flat diaphragm applied firmly to the skin best detects sounds of high frequency like those of the heart and lungs. The bell conducts low frequency sounds like the third heart sound (S3 gallop) in congestive heart failure. If the bell is applied too firmly, however, the skin beneath it may be stretched and act as a diaphragm; the bell will then pick up only high-frequency sounds.
- Palpation (Feel). Don't hesitate to use your hands. The fingertips are best suited for detecting textures and consistency; the back of the hand, for noting temperature.
- Percussion. The act of striking a part of the body with a short sharp blow in order to produce a sound is known as palpation. In the usual percussion technique, the middle finger of one hand is placed against the body wall and is struck a quick blow with the end of the bent middle finger of the other hand. The sound produced—the percussion note—gives information about the density of underlying tissues. Percussion may be difficult to evaluate in the field, where it is rarely quiet enough to appreciate the quality of percussion notes. But percussion may be a valuable tech-

nique in assessing, for example, the patient with a pneumothorax or hemothorax. If pneumothorax is present, the affected side will have a more hollow, or resonant, percussion note; in the presence of hemothorax, the percussion note over the affected side will be duller than that on the normal side.

After taking the patient's vital signs, observe the patient's general appearance and behavior. Does the patient appear comfortable or in distress? Is the patient frightened? Particular attention should be paid to the level of consciousness, since changes in the state of consciousness are often the first clues to an alteration in the patient's condition. The level of consciousness is especially important if the patient has sustained major traumatic injury, cardiorespiratory problems, intoxication with drugs, or a possible stroke.

Talk with the patient to determine the degree of alertness or confusion. Is the patient oriented to time (time of day, day of week, and date), place, person, and situation? The patient's speech should be noted. The victim's progressive slurring of words or vagueness when answering questions, especially if the victim's normal speech is clear and coherent, indicates a decreased level of consciousness. Garbled speech indicates the possibility of a stroke. If the patient cannot speak, determine whether the patient can understand by giving a simple command (e.g., "Squeeze my hand."). Estimate the alertness of young children and infants by noting their interest in their surroundings and by observing their voluntary movements. Find out what will arouse an unconscious or sleeping patient. If not verbal stimuli, will painful stimulus, such as a pinch, do the job?

If the patient moves in response to a given stimulus, note the nature of the movement. Is it purposeful? That is, does the patient try to move away from the painful stimulus or try to remove the noxious stimulation (e.g., by pushing the hand away)? Do both sides move equally well? Are hand grasps of equal strength? Can the patient wiggle his or her toes? When treating an unconscious patient, stimulate both arms or both legs simultaneously to test for equality of response. Does the patient show abnormal movements, such as decortication (flexion of the arms and extension of the legs) or decerebration (extension and internal rotation of the arms and extension of the legs)? Is there any movement at all?

Restlessness is common in many types of injuries and may indicate general discomfort, a full bladder, a reaction to restraints, or other problems. But restlessness is also one of the earliest signs of hypoxia (lack of oxygen) and internal bleeding and could be indicative of serious underlying problems.

When called upon to describe the patient's level of consciousness, avoid the words "stuporous," "lethargic," "obtunded," and the like. Such terms are not helpful because people seldom agree on their definitions. It is better to describe the patient's status in terms of the reaction to specific stimuli or responses to specific inquiries.

The evaluation of levels of consciousness using the AVPU method in the primary survey and the Glasgow Coma Scale in the secondary survey provides specific terms and numbers with which to chart the patient's course.

The color of the skin, especially in Caucasian patients, is a reflection of the circulation immediately underlying the skin as well as the oxygen saturation of the blood. In darkly pigmented individuals, these changes may not be apparent in the skin, but may be assessed by examining the mucous membranes. If the skin vessels constrict or cardiac output drops, the skin becomes pale, mottled, or cyanotic (a bluish discoloration). If cutaneous vessels dilate or blood flow increases, the skin becomes warm and pink. Pallor occurs if arterial blood flow ceases or extensive hemorrhage has occurred.

| Skin Color | Possible Cause |
|---|---|
| Red | Fever, allergic reactions, carbon monoxide poisoning |
| White (pallor) | Excessive blood loss, fright |
| Blue (cyanotic) | Hypoxemia; peripheral vasoconstriction from cold or shock |
| Mottled | Cardiovascular embarrassment (as in shock) |

Skin temperature rises as peripheral blood vessels dilate and falls as blood vessels constrict. Fever and high environmental temperatures stimulate vasodilation; shock usually causes vasoconstriction. Normal skin is fairly dry. Stimulation of the sympathetic nervous system, as in shock, causes sweating and moist skin. Depression of the sympathetic nervous system, as may occur with an injury to the thoracic or lumbar spine, can cause abnormally dry, cool skin in the affected areas.

| Skin Temperature | Possible Cause |
|---|---|
| Hot, dry | Excessive body heat (heat stroke) |
| Hot, wet | Reaction to increased internal or external temperature |
| Cool, dry | Exposure to cold |
| Cool, clammy | Shock |

**Examination of the head and neck.** The examination of the head begins the head-to-toe physical assessment. When a patient has sustained trauma, you should examine the neck at the completion of the resuscitation phase, so that any suspected cervical fractures can be immobilized before manipulating the patient further. In this presentation, however, the secondary survey will be described in a cephalocaudal (head-to-toe) direction.

When examining the trauma patient, check the scalp for lacerations and contusion. Is there blood in the hair? Where is it coming from? Do not move the head during this procedure. Check the back of the supine patient's head for blood by gently sliding a hand beneath it and palpating, feeling for tenderness or depressions indicative of fracture. Pay particular attention to the area over the mastoid bone, just behind the ear. Bluish discoloration (ecchymosis) of this area is called Battle's sign and indicates a probable basilar skull fracture. Check the ears and nose for discharge of clear fluid or blood. Blood draining from the ears may be a sign of skull fracture; clear fluid draining from the nose or ears may be cerebrospinal fluid, again indicating probable skull fracture. (If fluid is draining from the ears or nose, no attempt should be made to stop the flow.) Inspect the mouth for blood or foreign materials, such as broken dentures, that might be aspirated. The lips should be observed for cyanosis in patients with trauma or suspected cardiorespiratory problems.

The eyes should be examined in every patient. Is there trauma or swelling about the orbits? Is there ecchymosis around the eyes ("coon's eyes") without evidence of direct injury? This indicates a possible skull fracture. Check the sclerae (whites of the eyes) for icterus (yellow coloring indicating liver disease) or bloodshot appearance. The size and shape of the pupils should be noted. Are they equal in size? Do they react to light? If so, briskly or sluggishly? Pupils are normally round, equal, and briskly reactive to light. They may become constricted because of bright light, CNS disease, ingestion of some narcotics (including propoxyphen (Darvon), or parasympathetic stimulation. Dilated pupils occur with fright, pain, hypoxemia, brain injury, and certain drugs (such as atropine). Unequal pupils are normal in about 2 to 4 percent of the population, but suggest, in the rest of the population, cerebral edema or intracranial hematoma in the head-injured or stroke patient. Cataract surgery on one eye may also cause unequal pupil size, and the pupil of the operated eye will be nonreactive.

| Pupillary Sign | Possible cause |
|---|---|
| Dilated | Fright; brain ischemia; drugs (atropine) |
| Constricted ("pinpoint") | Narcotics overdose; disorders affecting the CNS; bright light |
| Unequal | May be normal (2 to 4 percent of the population); head injury; stroke; cataract surgery on one side |

Observe the motion of the eyes. Normally, the eyes gaze straight ahead unless focused on something. When the eyes move, they usually move together (conjugately). In head injury or direct trauma to the eyes, the gaze may be abnormal, that is, the eyes may turn in different directions or may not move together. This is known as dysconjugate gaze. If the patient is conscious, the paramedic should have him follow a finger with his eyes 180 degrees up, down, and to each side and should note whether his gaze is paralyzed in any direction. Patients with fractures of the orbit often have paralyzed upward gaze, while patients with stroke may have paralyzed gaze to the right or left. In the unconscious patient without evidence of neck injury, the paramedic should check for the doll's-eyes phenomenon: When the head of an unconscious person is turned rapidly to one side, the eyes move together toward the opposite side (doll's eyes). If the patient has brain injury, the doll's-eyes phenomenon may be lost and the eyes will move in the direction that the head is turned. This test should not be utilized in a trauma patient because of the possibility of C-Spine fracture.

When treating the trauma patient, gently palpate the back of the neck for tenderness. Examination of the neck and immobilization of the spine is the first priority when there is reason to believe that a spinal injury may have occurred. The absence of pain and tenderness and a normal neurological exam does not rule out a C-Spine fracture. Inspect and palpate the trachea to determine whether it is in the midline. The trachea will deviate toward an obstructed bronchus or a simple pneumothorax and away from a tension pneumothorax or significant hemothorax. Auscultation of the lungs to determine if breath sounds are absent on one side will establish the significance of a deviated trachea. In medical patients, the jugular veins should be checked for distention, as described under "Cardiovascular Assessment."

In the primary survey, respiration and circulation are of major importance. In the more detailed secondary assessment outlined here, respiration and circulation retain their major importance. The more sophisticated techniques described here should be used in addition to rather than instead of primary survey methods learned as part of Emergency Medical Technician-Ambulance training.

Respiratory assessment begins with the measurement of breathing rate and rhythm. The normal adult takes about 16 breaths per minute; a child or infant, about 24 breaths per minute.

Respiratory disturbances caused by CNS problems include Cheyne-Stokes breathing and central neurogenic hyperventilation. Cheyne-Stokes breathing may be caused by different neurologic and metabolic derangements, many of which can be corrected. In this pattern, periods of rapid, irregular breaths—starting shallowly, becoming deeper, then becoming shallower—alternate with periods of apnea (temporary cessation of breathing); the cycle repeats every 30 seconds to 2 minutes, with 5- to 40-second periods of apnea.

Central neurogenic hyperventilation is often a grave sign. It is characterized by very deep, rapid respirations. (Abnormally deep respirations are called hyperpnea; abnormally rapid respirations are called tachypnea.) The breathing of the diabetic patient in ketoacidosis may also be characterized by hyperpnea and tachypnea, and is called Kussmaul breathing.

While noting respiratory rate and rhythm, the paramedic should inspect the chest to determine its shape and symmetry. Is the chest barrel shaped, suggesting chronic obstructive pulmonary disease? Is one side flat or bulging? Is the spine abnormally curved? All of these deformities point to possible respiratory problems that may limit lung movement. In trauma victims, the patient should be inspected also for bruises.

The paramedic should observe the respiratory cycle. Normally, inspiration is active and exhalation is passive. In diseases such as emphysema, the lungs are overinflated and the patient must use accessory muscles in the neck and abdomen to assist respiration. Expiration also becomes active when airway obstruction is present and the patient uses the abdominal muscles to force the diaphragm up. Cardinal signs of respiratory distress include flaring of the nostrils, tugging of the trachea, use of accessory muscles in the neck and abdomen, and retraction of the intercostal and suprasternal spaces during inspiration.

Listen carefully as the patient speaks. A spinal cord injury in the cervical area would paralyze the diaphram, forcing the patient to breathe only with intercostal muscles. Should this occur, the patient would be able to speak only a few words before stopping for breath. A patient with severe dyspnea may also speak in short phrases.

To confirm the findings of inspection, palpate the chest, checking for symmetry of respirations by placing the tips of the thumbs on the xiphoid process (the lower end of the sternum) and spreading the hands over the lower rib cage. Both hands should move an equal distance with each breath. In trauma patients, the paramedic should palpate also for tenderness and instability over the ribs and for air crackling beneath the skin (subcutaneous emphysema), which is often associated with pneumothorax.

Palpate the trachea during deep inspiration. A pendulum motion of the trachea is a clue to bronchial obstruction. When a bronchus is obstructed, the lung that it supplies cannot inflate. During inhalation, the other, unaffected lung fills with air and swings toward the obstructed lung, temporarily displacing the trachea. On exhalation the trachea returns to its normal position.

Perform the percussion tests over both lung fields. Is the note from one side of the chest dull, suggesting fluid accumulation? Or hyperresonant, suggesting possible pneumothorax? Or both sides hyperresonant, suggesting severe asthma or emphysema?

Auscultation of the chest is designed to determine the equality of breath sounds and the presence of abnormal sounds. First listen to be sure breath sounds are present and are equal on both sides of the chest. Absent breath sounds on one side may indicate bronchial obstruction, pneumothorax, hemothorax, or—in the intubated patient—passage of the endotracheal tube down the mainstem bronchus of the other lung. When listening for abnormal sounds, remember that fluid transmits sound better than air. Most abnormal sounds in the lungs are caused by fluid, in the form of edema fluid, pus, or large amounts of mucus.

Abnormal lung sounds include rales, rhonchi, and wheezes. Rales are fine, crackling sounds that always indicate the presence of fluid. As more fluid accumulates, rales become louder. Rales resemble the sound made by rolling a few strands of hair near the ear. Rhonchi are harsher sounds and come from fluid collections in the larger airways or from a solid partial obstruction in the bronchus. Wheezes are high-pitched whistling sounds made when air flows through narrowed airways. Diffuse wheezing on expiration is prominent in asthma, and may be heard in left heart failure or pulmonary embolism as well. Wheezes localized to one section of the chest suggest focal obstruction.

When checking for breath sounds, always listen anteriorly and posteriorly, in at least four quadrants, comparing left and right sides at each level. In a pneumothorax, air usually rises and the lung falls back and down. Therefore the presence of this condition is detected by listening just below the clavicle on both sides and comparing the sounds. External sounds make this differentiation very difficult in an ambulance or at the trauma scene. Experience and concentration are necessary to make the correct diagnosis.

Stridor, a harsh, high-pitched sound, resembling a bark, is produced by an obstruction of the upper airway, either by foreign material or swelling.

Coughing is a response to bronchial irritation. Simple chemical irritation from aspirated material or smoke may cause a cough. Repeated coughing indicates that the cough is caused by irritation alone or that it is ineffective in clearing the airways. If a cough produces sputum, take notice of its color, consistency, amount, and odor. Mucus is white or clear. Purulent (infected) sputum is usually yellow or green. The coughing up of blood (hemoptysis) may indicate cardiac or pulmonary disease.

Cardiovascular assessment requires an examination of both the heart and blood vessels. It belongs with the vital signs, during which the pulse and blood pressure are taken. In the secondary survey, the venous pressure should also be assessed. The height of blood in the jugular veins of the neck is an indirect measure of the pressure in the right side of the heart. The patient should be placed in a semisitting position at a 45 degree angle. The paramedic should shine a light along the neck at a tangent so that the jugular vein stands out in relief. The venous pressure is described by determining the distance from the sternal angle to the top of the jugular column; for example, "The jugular veins are distended 10 centimeters (4 inches) above the sternal angle with the patient at 45 degrees." Marked jugular distention indicates an elevated right heart pressure, as in right heart failure or pericardial tamponade.

Ausculate the heart to determine the apical heart rate. Any discrepancy between the apical pulse rate and the rate measured at the wrist should be noted. Listen also for irregular rhythms. Any patient with an irregular rhythm should be monitored.

Of the many extra sounds that can occur in normal or diseased hearts, the third heart sound (S3) is probably the most important in the field, but it may be very difficult to detect unless the area where the examination is being performed is quiet. In adults, the third heart sound usually indicates congestive heart failure. Listen for this sound with the bell of the stethoscope pressed lightly over the apex of the heart. If present, the S3 will be heard as a soft extra sound immediately following the "dubb" of the "lub-dubb" sequence. The rhythm of the S3 can be mimicked by repeating the word "Kentucky" rapidly.

Further evaluation of the cardiovascular status is accomplished during examination of the back and extremities for edema (as described in a section that follows), which indicated right heart failure.

In abdominal assessment, it is simplest to examine patients in the most relaxed position possible. This means keeping them warm and flexing their hips and knees to decrease pressure on their abdominal wall. Talk to the patients while examining them to relieve tension and distract them from the examination.

The position in which the patient is lying can give important information about possible pathology within the abdomen. Is the patient lying quietly in the supine position, in the fetal position, on the side, or writhing in pain? Lying quietly usually indicates peritoneal irritation and intra-abdominal tenderness; whereas writhing in pain usually indicates retroperitoneal pain such as found with a ureteral stone.

The abdominal examination, like any other part of the physical examination, can be divided into look, listen, and feel segments.

Look—Evaluation of the abdomen by inspection will reveal:

- Distention—Is the abdomen protuberant? If so, does it stick out because of increased subcutaneous and intra-abdominal fat or is there a relatively thin abdomen distended over increased abdominal contents? These increased contents can be air distending the intestinal lumen or fluid such as ascites (serous fluid) between the loops of intestine. Air usually distends the abdomen anteriorly but fluid also distends the flanks.
- Surface—Are there bruises or ecchymoses overlying the anterior abdominal wall? Abdominal ecchymosis in the flanks or around the umbilicus (Cullen's or Turner's sign) are later signs of bleeding just as ecchymosis around the mastoid (Battle's sign) or a "black eye" and may not appear until up to 24 hours after the injury.
- Acute contusions or abrasions—These can indicate trauma to the organs in that quadrant (e.g., ruptured spleen with lateral upper quadrant contusion). Lacerations or penetrating wounds should be noted. Wounds of entrance and exit in penetrating trauma may suggest the organs involved. Lacerations should be examined for possible evisceration (extrusion of the internal organs). Is the abdomen scaphoid (concave) in appearance indicating malnutrition or severe retraction of the intra-abdominal muscles?

Listen—Presence or absence of bowel sounds or any abnormal bowel sounds are very important. Because intra-abdominal trauma or injury frequently causes bowel sounds to disappear, it is extremely important to know whether they were present during the initial examination and when they disappeared.

Bowel sounds may be described as normal (or active), hyperactive (meaning more frequent than would be expected), hypoactive (very infrequent), absent, or borborygmi. Borborygmi are high-pitched, tinkling bowel sounds that resemble sounds produced in a long thin lobe-shaped balloon containing mostly air with some water as the water trickles across the constrictions. These high-pitched, tinkling bowel sounds indicate intestinal obstruction, and often occur at the same time the patient complains of sharp, stabbing, cramping abdominal pain.

In order to properly evaluate bowel sounds, listen to the abdomen for at least 5 minutes. Listening for a shorter period can create false impressions.

Feel—When examining the abdominal cavity by palpation, the paramedic should check for the following:

- Muscular guarding—Is the abdomen rigid and broadlike (4+ guarding)? Or softr so that the posterior abdominal wall is easily palpated (O guarding)? Or is it somewhere in between (1+, 2+, 3+ guarding)?
- Tenderness—Where is the tenderness located? Is it severe, moderate, or mild? Ask the patient to specifically pinpoint the pain. If possible, locate the pain with one finger. Can pain be produced by palpating in other areas? If so, does the pain radiate? And to where?
- Masses—Are any abnormal masses palpable within the abdomen? Are any organs enlarged? If so, is the enlargement tender? Are there abdominal pulsations?
- Rebound tenderness—Rebound tenderness indicates peritoneal irritation. Any movement of the peritoneum can produce this sign. It can be confusing to both the original examiner and later examiners if this sign is elicited by pressing on the abdomen and rapidly releasing pressure. The patient will not be expecting this release and will tighten the abdominal muscles in later examinations to prevent further rebound pain. This will give later examiners a false impression about the amount of muscle guarding. A much more effective way to elicit rebound tenderness is to shake

the stretcher, gently shake the patient's hips, tap on the heel with the knee locked, or ask the patient to cough. Each of these will produce enough peritoneal movement to cause pain if inflammation exists, but none will confuse the very important sign of muscular guarding.

## ASSESSMENT OF THE EXTREMITIES AND BACK.

Evaluation of the back should be separated into three segments: cervical spine, thoracic spine, and lumbar spine. In the evaluation of each of these segments, the paramedic should keep in mind the following:

- Excessive movement of the patient is to be avoided.
- Tenderness over a particular vertebral body, malposition of the body, or pain and tenderness in the area indicate possible fracture.
- Ability to move a part does not necessarily mean that no fracture is present. It is particularly dangerous to ask the patient to move his neck and, if he can, to assume that he does not have a cervical spine fracture.
- A normal neurological exam means that the spinal cord is intact, but it does not mean that the bony structure surrounding the cord is not fractured.
- Fractures of the lumbar region and fractures of the pelvis (particularly the hip) are difficult to separate clinically in the hospital and in the field. It is not unusual for a fracture of the pelvis, particularly a fracture dislocation of the hip, to present initially with confusing pain patterns.
- Fracture of the lumbar region and, occasionally, lower thoracic region (particularly anterior compression fractures associated with seatbelt-type injuries) can present with abdominal findings alone. This is because the spinal cord has already splayed into the cauda equina; therefore, a lumbar fracture may not cause distal neurological problems. The injury may cause retroperitoneal hemorrhage and involve the sympathetic chain producing abdominal pain and absent bowel sounds. Contusion to the anterior wall can further confuse the picture by adding tenderness and muscular guarding.

In the trauma patient, the paramedic should inspect the extremities for bruises and deformities, always checking for the presence of a pulse, sensation, and motion distal to an injury, for example, the dorsalis pedis pulse and movement and sensation in the foot in the case of a femoral fracture. The adequacy of circulation to the extremities may also be gauged by the relative warmth of the limb and the degree of capillary refill in the nailbed. To assess capillary refill, gentle pressure should be exerted on the nailbed, sufficient to whiten the underlying cutaneous tissue. Then the pressure should be released and the rate at which the nailbed becomes pink again should be observed. If there is good circulation of the extremity, the capillaries should refill almost instantly, with prompt return of a pink coloring beneath the nail. Refill time greater than two seconds is definitely abnormal.

In all patients, the paramedic should check for strength and equality of peripheral pulses. The quality of these pulses deteriorates with decreased cardiac output, or arterial emboli. The pulse is stronger in arteriosclerosis (hardening of the arteries). The farther away the pulse is from the heart, the more its strength determines the heart's ability to supply blood to peripheral tissues. Thus, if a radial pulse is palpable, the blood pressure is usually above 80 to 90 systolic; if a carotid pulse is palpable, the pressure is generally above 70 to 80 systolic; and a palpable femoral pulse usually indicates a blood pressure of at least 60 systolic. A normal pulse is full, easily palpable, and equal to the corresponding pulse on the opposite side. If peripheral circulation is poor, the pulse becomes thready and weak, then intermittent, and finally disappears. The paramedic should use the radial and pedal pulses to check peripheral circulation, since these are the most distal pulses in the body. If these are poor or absent, the carotid and femoral pulses should be checked.

The sudden disappearance of a pulse in one extremity, together with sharp, sudden, severe pain in the limb may indicate occlusion of an artery in that extremity. Numbness, weakness, and tingling follow the pain. The skin gradually turns mottled, blue, and cold.

In patients who have sustained trauma, the paramedic should check the pelvic area for fractures and look for abnormal positioning of the legs. A leg that is abducted and externally rotated suggests a hip fracture. The entire pelvic bone structure as well as both legs should be palpated for protrusions, depressions, abnormal mobility, and tenderness.

In all patients with possible spinal injury as well as those with suspected stroke, the paramedic should check strength and sensation in all extremities. The patient with a spinal injury may manifest paraplegia (paralysis of both legs) or quadriplegia (paralysis of all four extremities); the stroke patient is more likely to have hemiplegia (paralysis of an arm or leg on the same side of the body). The loss of voluntary movement in the extremities is usually accompanied by loss of sensation in those extremities. Sometimes, however, the ability to move may be preserved, and the patient complains only of numbness or tingling in the extremities. It is of upmost importance that the paramedic recognize this finding as a sign of probable spinal injury and appropriately immobilize the patient.

The approximate level of injury can be gauged by testing for sensation with a pin, starting at the feet and moving upward. As a rough guide, the umbilicus is approximately at the level of the 10th thoracic nerve distribution (T10), the nipple line is around T4 or T5, and the clavicles are at about the third cervical nerve distribution (C3). Thus, if sensation is absent all the way up to the ribs, but present at the nipple line, the injury is likely to be somewhere between the 5th and 10th thoracic vertebrae.

In cardiac patients, as mentioned previously, the paramedic should also examine the extremities for edema, which often indicates right heart failure. However, edema localized to a single extremity may point to occlusion of a vein or artery by embolus, trauma, or external pressure (e.g., from an air splint or pressure dressing).

In trauma patients, after assessing the extremities for strength and sensation, the paramedic should gently palpate the spine for localized tenderness but should avoid moving the patient in the process. The lower back of cardiac patients should be examined for evidence of edema.

## Putting It All Together

Circumstances will dictate which aspects of the physical examination are most relevant and merit more emphasis. The physical exam will be influenced by whether the patient is suffering from a medical problem or is the victim of trauma, whether the patient is conscious or unconscious, and whether life-threatening conditions are present. Examples of approaches to different situations are given in Table 2.1. Remember to first conduct the primary survey and correct any problems it uncovers.

### *Initial Management of the Trauma Victim*

In this section, physical assessment of the trauma victim is described in more detail. In managing trauma situations, particularly motor vehicle trauma, the paramedic must change the initial phase to fit the situation. Management of trauma can actually be divided into four segments, rather than the two segments of primary and secondary survey. Initial evaluation or primary survey is followed by the secondary survey. Resuscitation is followed by definitive care.

As an EMT, your first priority at any level of skill or training is to protect yourself. An injured EMT compounds any existing problem and has done much more harm than good for the patient.

Burns—Although the management of burns is not of primary importance, burn prevention is. The first procedure carried out when entering a car is not to open the patient's airway, but instead to turn off the car's ignition. Any car that has an electric fuel pump and has its ignition on can ignite, because the electrical system can create a spark near the gasoline pumped by the fuel pump. Turning off the ignition does not completely disconnect the car's electrical system. To do this, the paramedic needs to cut the battery cables. However, in a life-threatening situation, opening the hood to cut the battery cables may significantly delay patient evaluation and management. Therefore, the ignition should be turned off first.

Airway—Maintaining oxygenation of the brain is of primary importance when first treating the trauma victim. In cardiac arrest, simply opening the airway assures patency of the pulmonary system. When evaluating a trauma patient, however, you must also consider possible tension pneumothorax, flail chest and open pneumothorax.

Maintaining the airway is also different in trauma than in the ordinary cardiac arrest patient. Simple hyperextension of the head effectively opens the airway. But you must assume that any unconscious patient has cervical spine injuries, and you, therefore, must avoid hyperextending the patient's head. The rescuer may use the jaw-jut method to open the airway, either by placing the thumb behind the incisors and pulling the unit forward or by placing the fingers behind the angle of the mandible and pulling it forward. (See Chapter 5.) This will ensure an open airway without risking cervical cord damage when there is possible cervical spine injury. Mechanical means such as oral airway, nasal endotracheal tube, esophageal airway, or nasal airway may also be used. Do not use an oral endotracheal tube when there is a possible cervical spine fracture unless you are experienced enough at inserting it to do so without moving the neck and help is available to provide in-line Traction.

After the airway is open, make sure that enough air is moving into the lungs to oxygenate the brain adequately.

Breathing—The airway is separated from breathing problems by the larynx. The problems below the larynx which restrict adequate respiration are flail chest and an open or tension pneumothorax.

Circulation—Evaluation of cardiac status is covered in Chapter 6. The following points need to be stressed, however:

- Circulation is rapidly evaluated by checking the pulse. Is it weak, thready, strong, pounding or full? Where is it most easily detected (radial, femoral, carotid)? What is the capillary refilling time? These simple techniques can identify much about the adequacy of circulation. A blood pressure determination is not essential to the primary survey.
- Car seats (like hospital beds) cannot be used for cardiopulmonary resuscitation (CPR). The paramedic must first put a backboard under the patient or move the patient to the pavement or other solid surface.
- Blood, like water, runs downhill when the patient is in the upright position. In the upright position, CPR will oxygenate the great toes of both feet but will do little for the cerebral cortex. Therefore, patients should be supine and have their legs elevated, if possible.

## Table 2.1 Sample Priorities in the Physical Examination

| Trauma Patient | Cardiac Patient | Stroke Patient |
|---|---|---|
| Primary survey | Primary survey | Primary survey |
| Vital signs | Vital signs | Vital signs |
| ?Neck injury or other spinal injury | | |
| Skin temperature moisture, color | Skin temperature moisture, color | Skin temperature, moisture, color |
| Evidence of head injury | | |
| Eyes:<br>?Conjugate gaze<br>?Range of motion<br>?Pupillary signs | | Eyes:<br>?Conjugate gaze<br>?Range of motion<br>?Pupillary signs |
| Ears:<br>?Blood in canals<br>?CSF<br>?Battle's sign | | |
| Nose:<br>?Blood<br>?Foreign material<br>?Cyanosis of lips | | |
| Mouth:<br>?Cyanosis of lips<br>?Foreign material | Mouth:<br>?Cyanosis of lips | |
| Neck:<br>?Tracheal deviation | Neck:<br>?Distended jugular veins | |
| Chest:<br>?Bruises<br>?Asymmetry<br>?Unequal breath sounds | Chest:<br>Rales, wheezes | |
| Heart rate and regularity | Heart rate and regularity | Heart rate and regularity |
| Abdomen:<br>?Distention<br>?Masses<br>?Ecchymosis<br>?Bowel sounds | Abdomen:<br>?Distention | |
| Extremities:<br>?Deformity<br>?Bruises<br>?Equality of pulses<br>?Strength, sensation | Extremities:<br>?Edema<br>?Equality of pulses | Extremities:<br>?Equality of pulses<br>?Strength, sensation |
| Back:<br>?Spinal tenderness | Back:<br>?Edema | |

- Flail chest is not a contraindication to CPR. The objective during CPR is to squeeze blood out of the heart. This is accomplished by compressing the heart between the sternum and the vertebral column. With a flail chest, less force is needed to do this. Therefore, effective cardiac output can be obtained in spite of flail chest, although it may require as little pressure as needed in an infant.

Hemorrhage. The paramedic should consider hemorrhage early in priorities and control loss by direct pressure. Treatment of minimal blood loss from abrasions and lacerations should be delayed until the definitive care stages. Hemorrhage should be controlled in the field and after arrival in the emergency department by direct pressure. There is seldom, if ever, a reason to use either hemostats or tourniquets until the patient is stabilized and definitive care started. Tourniquets cause problems in three ways:

- If improperly applied, a tourniquet can damage an artery and necessitate either replacement of the artery or amputation of the limb.
- Total ischemia (constriction or obstruction of a blood vessel) causes anoxic metabolism in the extremity; this produces lactic acid. Release of excess lactic acid into the systemic circulation when the tourniquet is removed can produce total body acidosis. Therefore, the paramedic should give one or two boluses of sodium bicarbonate just before the release of tourniquet.
- An improperly applied tourniquet will obstruct only the venous outflow and, therefore, actually increase blood loss.

Hemostats can also be harmful when used to control hemorrhage. There are several reasons for this:

- Excessive blood can be lost while groping for a bleeder that could be easily controlled by direct pressure. The paramedic should apply direct pressure with sterile gauze (4 x 4's) or should use the open hand or a single finger.
- In appropriately applied hemostats (not vascular clamps) can damage an artery and convert a partial laceration into a full circumferential injury. To repair this damage, the injured section must be surgically removed and the two ends joined together. A blood-vessels graft may even be necessary if the injured section is large.
- With a wound full of blood, it is difficult to identify an individual bleeder without appropriate lighting, suction, and operating room conditions. Other structures, such as nerves, can be accidentally clamped and injured by carelessly applied hemostats.

## NEUROLOGIC STATUS

Dilated pupils. The paramedic should evaluate neurological status including unilateral pupil dilation and level of consciousness in the primary survey and again in the secondary survey. Deteriorating level of consciousness, unilateral pupil dilation, or change in the size of the pupils can indicate a rapidly expanding intracranial mass, such as subdural or epidural hematoma. This is one of the few emergencies that is difficult to treat in the field. It necessitates immediate loading and transportation to the closest appropriate medical facility for intracranial decompression.

Consciousness. Level of consciousness is determined by the AVPU method.

A–Alert
V–Responds to vocal stimuli
P–Responds to painful stimuli
U–Unresponsive

### Phase I: Resuscitation.

The primary survey can be accomplished in less than 30 seconds if no life-threatening problem exists. Life threatening problems of airway, breathing, and circulation should be solved when found.

- Control hemorrhaging.
- Begin oxygen administration.
- If necessary, apply Military Antishock Trousers (MAST).
- Start appropriate IV's.

### Phase II

Do not allow difficulty in performing any one of these steps to stop you from performing the others. The establishing of IV lines is frequently a stumbling block, but the task is much easier if you apply the MAST before attempting to identify veins.

The arterial damage accompanying a fracture can be so extensive that changing the position of the bones will not reestablish vascular continuity. Make only one or two attempts at removing the obstruction through manipulation. If you fail, return the limb to the most in-line position.

Know your limitations. Unnecessary delay in accomplishing these steps can harm the patient, so ask for help from a partner or consider immediate transportation if completion of any step is vital. The patient's priorities and general condition should always be considered—a difficult step may be superfluous.

### Phase III: Secondary Survey.

You should now evaluate the patient systematically, being quick but not careless. Begin the survey at the top of the head and end it with an evaluation of the great toes bilaterally.

- Use the standard look, listen, and feel approach.
- Look at the skin, identifying depressions, abnormal contours, abrasions, ecchymoses, lacerations, or hemorrhage.

- Palpate for abnormal masses, areas of tenderness, or unstable bones. With the exception of the cervical spine, palpate each bone throughout its length and manipulate it through a full range of motion. Apply gentle three-point pressure to stress the bone. As this is done, identify crepitation, unusual movement, or pain—indications of possible fracture.

After identifying all problems, wounds should be dressed, and the patient immobilized for transportation.

### Phase IV: Contact medical facility.

After completing the physical assessment, contact an appropriate medical facility and describe the situation. Identify the problems; describe the treatment rendered; advise the facility on subsequent treatment. Be concise.

## *Presenting Medical Information*

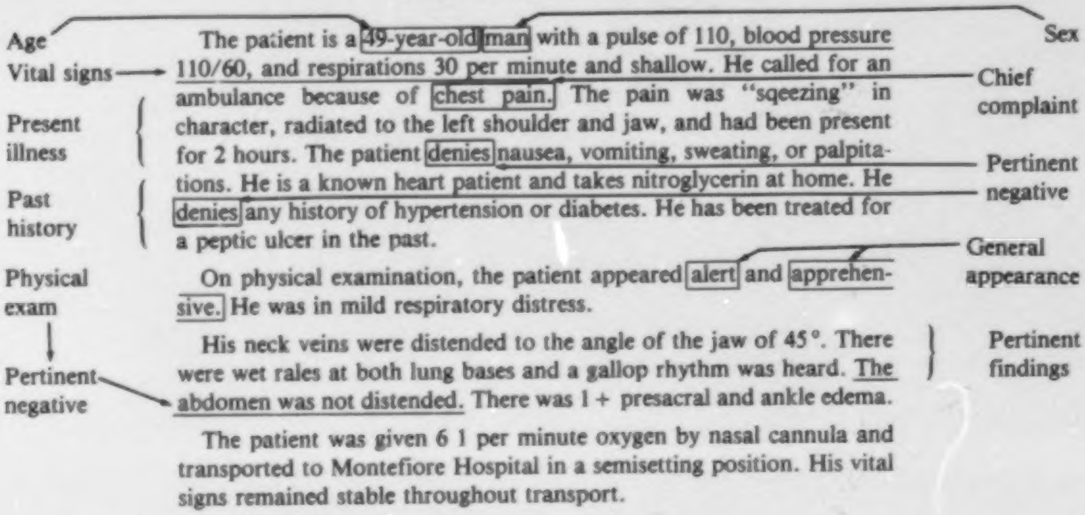
When you arrive in the emergency department or write your report, it is important to present information in an orderly, concise fashion. This allows for: (1) better communication with the emergency department staff, (2) a safeguard against omitting important details, and (3) the production of a document that is a thorough, accurate record of the case, in the event it is used in court. What follows is the traditional format for presenting medical information:

- Age and sex of the patient.
- Vital signs.
- Chief complaint—The reason the patient called for help (e.g., chest pain).
- Present illness—An elaboration of the chief complaint (e.g., What was the pain like? Where did it radiate? How long had it been present? Did anything make it better or worse? Had the patient ever had symptoms like that before? Were there any other related symptoms?).
- Past medical history—Significant illnesses or injuries, medications, allergies.
- Physical examination—General appearance; is the patient comfortable or in distress? Level of consciousness. Pertinent findings, in order from head to toe.
- EKG findings, if patient was monitored.
- Treatment given in the field.
- Condition during transport—Position in which patient was transported should be noted. Any changes in vital signs or other conditions also should be noted.

You will not confuse the information that belongs in the history with what belongs in the physical examination if you keep in mind that a history can be taken over the telephone without ever seeing the patient, but that a physical examination can be done on a patient who cannot communicate.

A sample case presentation, with components labeled, is presented below. Take note of the pertinent negatives—features that, based on knowledge of a certain condition, you would expect the patient to have, but on questioning denies having. For example, the patient described is in congestive heart failure, and a condition that predisposes one to heart failure is hypertension. On questioning, however, this patient denied any history of hypertension. Pertinent negatives should also be noted in the physical examination. You would expect a patient who is overdosed on heroin to have constricted pupils; if they are not, this should be mentioned. Pertinent negatives can be more informative than the positive information obtained.

### Sample Case Presentation



The patient is a 49-year-old man with a pulse of 110, blood pressure 110/60, and respirations 30 per minute and shallow. He called for an ambulance because of chest pain. The pain was "sqeezing" in character, radiated to the left shoulder and jaw, and had been present for 2 hours. The patient denies nausea, vomiting, sweating, or palpitations. He is a known heart patient and takes nitroglycerin at home. He denies any history of hypertension or diabetes. He has been treated for a peptic ulcer in the past.

On physical examination, the patient appeared alert and apprehensive. He was in mild respiratory distress.

His neck veins were distended to the angle of the jaw of 45°. There were wet rales at both lung bases and a gallop rhythm was heard. The abdomen was not distended. There was 1+ presacral and ankle edema.

The patient was given 6 l per minute oxygen by nasal cannula and transported to Montefiore Hospital in a semisetting position. His vital signs remained stable throughout transport.

The history and physical exam are always presented in the same order, regardless of the sequence of events in the field. Thus, even though oxygen might be given to a cardiac patient before the history is taken, you still mention oxygen administration near the end of the report when discussing treatment.

### *Triage*

In discussing patient assessment, the assumption was made that there was only one patient. But often, especially in trauma cases, there will be more than one. You will, therefore, need to triage the patients, that is, sort them according to the severity of their injuries. The purpose of triage is to ensure that patients with life-threatening conditions receive immediate treatment. Therefore, the first priority includes patients with airway and breathing problems, cardiac arrest, uncontrolled bleeding, severe head injuries, and open chest or abdominal wounds. Also of first priority are patients with severe medical problems, including poisoning and heart attack, patients with severe burns, and patients who are in shock. Patients of second priority are those with less serious burns, multiple fractures, and back injuries associated with spinal cord injuries. In the third priority are patients with minor fractures and other minor injuries. Also included in the third priority are patients who are already dead or obviously mortally wounded.

A sample triage situation follows:

You arrive promptly (within 2 minutes) at the scene of a two-car collision. The driver of the first car is slumped over the steering wheel; sitting beside him is a very distraught, but apparently uninjured middle-aged woman. The driver of the second car is conscious, alert, and complaining loudly of pain in the left arm and right leg.

You move quickly to the side of the first driver and determine that he is not breathing and has no palpable pulse. While doing this, the woman seated beside him informs you that he complained of crushing chest pain shortly before the accident.

In this case, the driver of the first car is obviously the first priority, and the paramedic should remove him from the car and begin CPR immediately, taking care not to injure his cervical spinal cord should there be a cervical fracture. The driver of the second car is second priority; the female passenger in the first car is third priority.

## Glossary

**abduction:** A movement away from the central axis of the body.

**acetabulum:** The cup-shaped cavity on the external surface of the innominate bone in which the rounded head of the femur fits.

**adduction:** A movement of a limb or a bending of the head or trunk toward the center of the body.

**adrenal gland:** A small gland in the superior aspect of each kidney; produces corticosteroids, catecholamines, and a variety of other hormones.

**alveolus:** A socket made of bone for the teeth; a lung air cell.

**anterior:** Situated in front of or in the forward part of; in anatomy, used in reference to the ventral or belly surface of the body.

**anus:** The outlet of the rectum lying in the fold between the buttocks.

**articulation:** The connection of bones; a joint.

**atrium:** The thin-walled chamber of the heart; the right atrium receives venous blood from the vena cava; the left atrium receives oxygenated blood from the pulmonary veins.

**auscultation:** The technique of listening for and interpreting sounds that occur within the body, usually with a stethoscope.

**bile:** A fluid secreted by the liver that is concentrated and stored in the gallbladder and then discharged into the intestine where it aids in digestion of fats.

**bronchus:** One of the two main branches of the trachea that lead to the right and left lungs; any of the larger air passages of the lungs.

**carpals:** The eight small bones of the wrist.

**caudad:** Toward the bottom of the body.

**cerebrospinal fluid:** The fluid contained in the four ventricles of the brain and the subarachnoid space around the brain and spinal cord.

**cervical:** Pertaining to the neck.

**Cirvix:** The lower portion, or neck, of the uturus.

**Cheyne-Stokes respiration:** An abnormal breathing pattern characterized by rhythmic waxing and waning of the depth of respiration, with regularly recurring periods of apnea; seen in association with central nervous system dysfunction.

**chief complaint:** The problem for which a patient seeks help, stated in a word or short phrase.

**clavicle:** The collarbone; attached to the uppermost part of the sternum at a right angle.

**coccyx:** The lowest part of the backbone; composed of four small fused bones; the tailbone.

**colon:** The part of the large intestine that extends from the cecum to the rectum.

**craniad:** Toward the cranium.

**cranium:** The skull.

**cyanosis:** A blueness of the skin due to insufficient oxygen in the blood.

**decerebrate posture:** A posture assumed by patients with severe brain dysfunction; characterized by extension and internal rotation of the arms and extension of the legs.

**decorticate posture:** The posture assumed by patients with a lesion at the brainstem level or above; characterized by tightly flexed arms, clenched fists, and slightly extended legs.

**distal:** Farthest from any point of the center or median line; in extremities, farthest from the point of junction of the trunk of the body.

**dorsal:** A term that refers to the back or posterior side of the body or an organ.

**duodenum:** The first 11 inches of the small intestine, extending from the pylorus to the jejunum.

**dysconjugate gaze:** A condition in which the two eyes are not aligned, but stare in different directions.

**ecchymosis:** An extravasation of blood under the skin causing a black and blue mark.

**epiglottis:** The lidlike cartilaginous structure overhanging the superior entrance to the larynx and serving to prevent food from entering the larynx and trachea while swallowing.

**esophagus:** The portion of the digestive tract that lies between the pharynx and the stomach.

**extension:** The process of straightening; the movement by which the two ends of any joined part are drawn away from each other.

**fallopian tube:** The tube extending from the ovary to the uterus.

**femur:** The bone that extends from the pelvis to the knee; the longest and largest bone of the body; the thigh bone.

**fibula:** The smaller of the two bones of the lower leg.

**flexion:** A term to describe a bending motion.

**gallbladder:** The sac located just beneath the liver that concentrates and stores bile.

**hemiplegia:** A paralysis of one-half of the body.

**hemeostasis:** A tendency toward constancy of or stability in the body's internal environment.

**hormone:** A substance secreted by an endocrine gland that has effects on other glands or systems of the body.

**humerus:** The bone of the upper arm.

**hyperpnea:** An increased depth of respiration.

**ileum:** The most distal portion of the small intestine lying between the jejunum and the colon.

**inferior:** Situated below, or directed downward; used to refer to the lower surface of an organ or structure.

**inspection:** The first part of the physical examination, involving a careful visual examination of the patient.

**jejunum:** The second portion of the small intestine.

**kidneys:** The paired organs located in the retroperitoneum that filter the blood and produce urine.

**lateral:** Of or toward the side; away from the midline of the body.

**larynx:** The organ of voice production.

**liver:** The large organ in the right upper quadrant of the abdomen that secretes bile, produces many essential proteins, detoxifies drugs, and performs many other vital functions.

**lumbar:** Refers to the region of the spine and surrounding trunk between the thorax and the brim of the pelvis.

**lymph:** An almost colorless nutrient fluid that circulates in the lymphatic vessels.

**mandible:** The lower jawbone.

**maxilla:** The upper jawbone.

**medial:** Toward the midline of the body.

**medulla oblongata:** The portion of the brain between the cerebellum and spinal cord that contains the centers for control of respiration, heart beat, and other major control centers.

**ovary:** The female gonad in which eggs and female hormones are produced.

**pallor:** A paleness of the skin.

**palpation:** The act of feeling with the hand for the purpose of determining the consistency of the part beneath.

**pancreas:** An intra-abdominal gland that secretes insulin and important digestive enzymes.

**paraplegia:** The loss of both motion and sensation in the legs and lower part of the body, most commonly due to damage to the spinal cord.

**parasympathetic nervous system:** A subdivision of the autonomic nervous system involved in control of involuntary functions; mediated largely by the vagus nerve through the chemical acetylcholine.

**patella:** A small, flat bone that protects the knee joint; the kneecap.

**percussion:** The act of tapping a part of the body; used as an aid in diagnosing the condition of the underlying body structures by the sound obtained by tapping with the fingers.

**pericardium:** The double-layered sac containing the heart and the origins of the superior vena cava and pulmonary artery.

**phalanx:** Any bone of a finger or toe.

**pituitary gland:** The master gland of the body, located in the brain behind the eyes; influences the secretions of all other glands.

**plasma:** The fluid portion of the whole blood; contains the red and white cells.

**posterior:** Situated in back of or behind a surface.

**prone:** A position of lying flat with the face downward.

**prostate:** The gland at the base of the male bladder that often becomes enlarged later in life and causes an obstruction of urine flow.

**proximal:** Closer to any point of reference; usually refers to closeness to the heart.

**quadriplegia:** A paralysis of both arms and legs.

**radius:** The bone on the thumb side of the forearm.

**rectum:** The distal portion of the large intestine.

**rhonchi:** Coarse rattling sounds somewhat like snoring, usually caused by secretions in the bronchial tubes.

**sacral:** Pertaining to the sacrum, a part of the pelvic girdle.

**scapula:** The shoulder blade.

**seminal duct:** The duct through which sperm pass into the seminal vesicles.

**stomach:** The hollow digestive organ in the epigastrium that receives food from the esophagus.

**stridor:** A harsh, high-pitched respiratory sound associated with severe upper airway obstruction.

**superficial:** Confined to or pertaining to the surface.

**superior:** In anatomy, used to refer to an organ or part that is located above another organ or part.

**supine:** Lying horizontal in a face-upward position.

**subcutaneous emphysema:** A condition in which trauma to the lung or airway results in the escape of air into body tissues, especially the chest wall, neck, and face; a crackling sensation will be felt on palpation of the skin.

**suture:** A type of fibrous joint in which the opposed surfaces are closely united; also, the material used in closing a surgical wound.

**sympathetic nervous system:** A subdivision of the autonomic nervous system that governs the body's "fight or flight" reactions and stimulates cardiac activity.

**tachypnea:** Excessively rapid rate of respiration (over 25 per minute in adults).

**tarsal:** Pertaining to the tarsus.

**tarsus:** The root of the foot, or instep; also, the fibrous plates giving solidity and form to the edges of the eyelids.

**testes:** Plural of testis.

**testis**: One of a pair of male reproductive glands that produce spermatozoa when sexual maturity is reached.

**thoracic:** Pertaining to the chest.

**thyroid gland:** A ductless endocrine gland lying in front of the trachea; produces hormones involved in metabolism regulation.

**tibia:** The larger of the two bones in the leg; shinbone.

**trachea:** The cartilaginous tube extending from the larynx to its division into the mainstream bronchial windpipe.

**ulna:** The larger bone of the forearm, on the side opposite that of the thumb.

**ureter:** Either of the tubes that convey urine from the kidneys to the bladder.

**urethra:** The canal that leads urine from the bladder to the urethral orifice.

**uterus:** The muscular organ that holds and nourishes the fetus, opening into the vagina through the cervix; the womb.

**vagina:** The canal in the female extending from the uterus to the vulva; the birth canal.

**ventral:** Referring to the belly; the anterior portion of the body

**ventricles:** The thick-walled muscular chambers in the heart that receive blood from the atrium and force blood into the arteries; also, any small cavity.

**vertebra**: Any one of 33 bones of the spinal column.

**wheeze**: A high-pitched, whistling sound characterizing an obstruction or spasm of the lower airways.

**zygomatic bone**: The cheekbone.

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# Module III.
# Shock and Fluid Therapy
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# Module III.

# Shock and Fluid Therapy

## Unit 1. Fluid and Electrolytes

### Body Fluids

The human body is composed chiefly of water, which provides the environment in which the chemical reactions necessary for life take place. Water also provides a transport medium for nutrients, hormones, and waste materials. The total body water (TBW) (see Fig. 3.1) makes up 60 percent of the weight of an adult. It is divided into intracellular fluid (ICF) and extracellular fluid (ECF); the two types of fluid are separated by the membranes, such as cell walls.

- ICF, the water contained inside the cells, normally accounts for 40 percent of body weight.
- ECF, or water outside the cells, accounts for 20 percent of body weight. It is further divided into

—Interstitial fluid, the water bathing the cells. Interstitial fluid accounts for about 15 percent of body weight. This category also includes special fluid collections such as cerebrospinal and intraocular fluid.

—Intravascular fluid (plasma), the water within the blood vessels. This carries red blood cells (RBC's), white blood cells (WBC's), and vital nutrients. Intravascular fluid normally accounts for about 5 percent of body weight.

Thus, in a 70-kilogram (kg) (154-pound) man, there are about 42 liters

(1) of water, distributed as:

- ICF = 28 1
- ECF = 14 1

—Interstitial fluid = 10.5 1

—Plasma = 3.5 1

### Salt Molecules

The other 40 percent of body weight is made up of the various organic and inorganic salts whose mole-

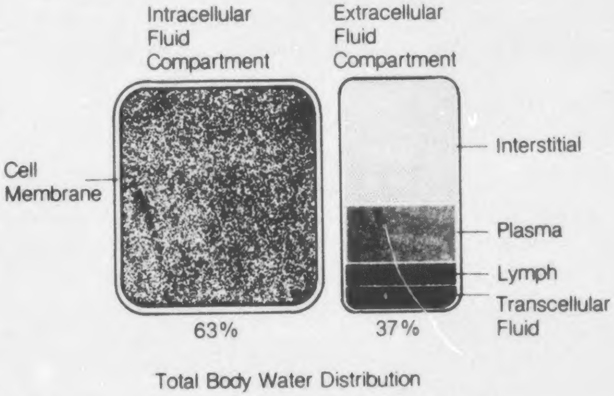

Intracellular Fluid Compartment
Extracellular Fluid Compartment
Cell Membrane
Interstitial
Plasma
Lymph
Transcellular Fluid
63%
37%
Total Body Water Distribution

**Figure 1. Distribution of Total Body Water**

cules are usually dissolved in water. The water is the solvent, and the dissolved molecules are the solute. Solute molecules can be classified as electrolytes and nonelectrolytes.

Electrolytes are substances whose molecules dissociate into electrically charged components called ions (cations and anions) when placed in water.

Ions with a positive charge are called cations, because they migrate toward the negative pole (cathode) when an electric current passes through the water. The most important cations in the body are sodium ($Na^+$), potassium ($K^+$), calcium ($Ca^{++}$), and magnesium ($Mg^{++}$).

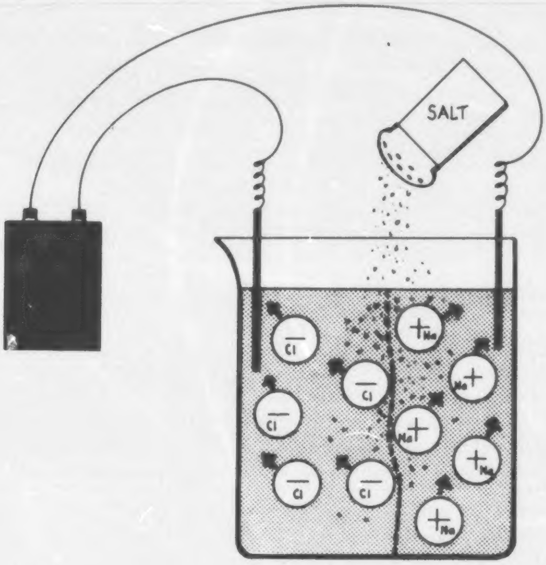


**Figure 2. Electric Current Passing Through Salt Water**

Ions with a negative charge are called anions, because these ions migrate toward the positive pole (anode) when electric current passes through the water. Among the most important anions in body metabolism are chloride ($Cl^-$), bicarbonate ($HCO_3^-$), and organic and inorganic acids.

Figure 3.2 illustrates what happens when ordinary table salt (NaCl) is dissolved in water through which an electric current is passed. The NaCl molecules dissociate into $Na^+$ ions (cations) and $Cl^-$ ions (anions), and each migrates toward the oppositely charged pole.

In physiologic solutions, the total milliequivalents of cation always equals the total milliequivalents of anion. The milliequivalent is a measure of the combining power of ions and is the expression of measurement of electrolytes in solution.

Oppositely charged ions attract each other and tend to recombine in solution. The number of ions an electrolyte combines with depends on the number of charges it carries (its valence). A monovalent ion has one charge and a bivalent ion has two charges. Each positive charge can combine with only one negative charge. The number of milliequivalents of an electrolyte is determined by the total number of charges carried by that electrolyte in the solution. Total charges equal the number of ions multiplied by the number of charges per ion. Each milliequivalent contains a standard number of charges expressed as millimole of charges. (The millimole is a unit that chemists use to describe numbers of particles.)

The following example illustrates how the valence of an ion affects its combining power and therefore the number of milliequivalents it contributes to a solution: $Na^+$ is a singly charged (monovalent) cation, and $Cl^-$ is a singly charged anion. Therefore, 1 milliequivalent (mEq) of $Na^+$ will react with 1 mEq of $Cl^-$ to form NaCl.

Since each $Ca^{++}$ ion has two positive charges (bivalent cation), each millimole of $Ca^{++}$ has 2 mEq of positive charges:

Total charges = 1 millimole (mmole) ions × 2 charges per ion = 2mEq charges

Therefore, each millimole of $Ca^{++}$ can combine with 2 mEq of anion.

The body fluids also contain nonelectrolytes, or solutes that have no electrical charge. These include glucose, certain proteins, and urea. Such solutes are usually measured in grams or milligrams. The normal concentration of glucose in the blood, for example, is about 70 to 110 milligrams (mg) per 100 milliliters (ml).

## Osmosis

As was noted previously, the body is made up of several fluid compartments separated from one another by membranes. The concentration of solute particles—whether electrolytes or nonelectrolytes—in these compartments is determined chiefly by a process called osmosis. If two solutions are separated by a semipermeable membrane (such as a cell wall), water will flow across the membrane from the solution of lower concentration to that of higher concentration—the net effect being to equalize the solute concentrations on the two sides of the membrane (see Fig. 3.3). The force that makes water move from an area of low particle concentration to an area of higher concentration is called osmotic pressure.

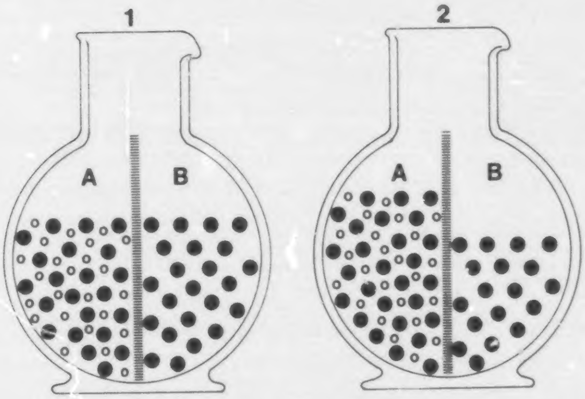
Figure 3.3 represents a cell which has been placed in a solution whose solute concentration is lower than that inside the cell. (The cell fluid is said to be hypertonic with respect to the solution; conversely, the solution is hypotonic with respect to the ICF.) Water moves from the solution of lower concentration across the cell membrane into the intracellular space, equalizing the solute concentrations inside and outside the cell (making them isotonic). As shown in the figure, the cell must expand its volume to accommodate the extra water. The tonicity of the solution or compartment depends on the amount of solutes present in it. A higher concentration of the solutes will render the solution hypertonic, and a lower concentration will render it hypotonic.

In a clinical situation, if you were to infuse pure water (without any solutes) into a patient's vein, the water would move in large quantities across the red cell membranes, since the solute concentration inside the RBC's is much higher than in water. There is a limit, however, to the ability of cell membranes to stretch, and eventually the walls of the RBC's would give way. For this reason, intravenous (IV) infusions are usually close to isotonic; that is, they have about the same solute concentration as the blood in order to minimize such fluid shifts.

In the extracellular fluid, the principal solute exerting osmotic force is sodium, which is normally present in a concentration of about 124 mEq per liter. Normal saline solution and IV fluid (which will be discussed later) contain 154 mEq of sodium per liter. Thus, they are very close to isotonic with the extracellular fluid.

## Diffusion of Solutes

Just as water molecules cross membranes to equalize water concentrations on both sides, solute molecules diffuse across membranes to equalize solute concentrations on the two sides. However, solute molecules cross membranes less freely than water molecules do. The rate of passage of solute molecules across body membranes depends on their size and relative ability to dissolve in membranes. Small solute particles cross membranes more freely than larger particles do, and uncharged molecules, which dissolve readily in lipid-containing membranes, cross membranes more easily than charged particles (anions and cations).



Effect of Osmotic Pressure

**Figure 3. Osmotic Pressure Effect**

Because it is charged, sodium (an anion) crosses cell membranes very slowly. Therefore, an isotonic NaCl (normal saline) infusion can be used to expand blood volume, because the sodium will not equilibrate across the blood vessel membrane for several hours.

Like normal saline, lactated Ringer's solution is an isotonic electrolyte solution. Because its anions and cations cross body membranes slowly, lactated Ringer's solution can also be used to expand blood volume. Electrolyte solutions like normal saline and lactated Ringer's are referred to as crystalloids.

Albumin, a large plasma protein, crosses membranes even less easily than crystalloids do. Therefore, infused albumin remains within the blood vessels for many hours and expands blood volume faster and more efficiently. Protein solutions like albumin are referred to as colloids.

## Active Transport

Glucose and amino acid molecules diffuse slowly through membranes. (Amino acids are small components of proteins.) The cells need a continuous supply of these molecules for metabolism, so cell membranes actively transport them into cells.

Active transport differs from diffusion in three ways. First, active transport can carry molecules from areas of low concentration to areas of higher concentration (against a concentration gradient). Second, active transport requires energy, while diffusion requires none. Third, it is faster than diffusion.

Because glucose enters cells rapidly, chemically isotonic glucose solution (D5W = 5-percent dextrose in water) behaves physiologically as if it were hypertonic. Infused glucose molecules rapidly leave the blood stream, leaving water behind. This makes the blood hypotonic relative to the extravascular space, so water then leaves the blood stream by osmosis. (Since D5W does not remain in the blood stream, it cannot be used to expand blood volume.)

## Review of Definitions

An isotonic solution is a solution having a concentration of solute molecules equal to that in the cells. Therefore, isotonic solutions (e.g., normal saline) administered intravenously to a normally hydrated patient will neither draw water out of the cells nor contribute water to the cells (see Fig. 3.4).

A hypotonic solution is a solution having a solute concentration lower than that of the cells. Therefore, when a hypotonic solution (1/2 normal saline) is infused intravenously into a normally hydrated patient, water will migrate from the solution into the cells (see Fig. 3.5).

A hypertonic solution is a solution having a concentration of solute molecules higher than that in the cells. When a hypertonic solution (D50W, 50-percent dextrose) is administered intravenously to a normally hydrated patient, it will draw water from the cells into the vascular space (see Fig. 3.6).

A crystalloid solution is a solution containing no proteins.

A colloid solution is a protein-containing solution. It stays in the vascular space longer and is useful in maintaining vascular volume.

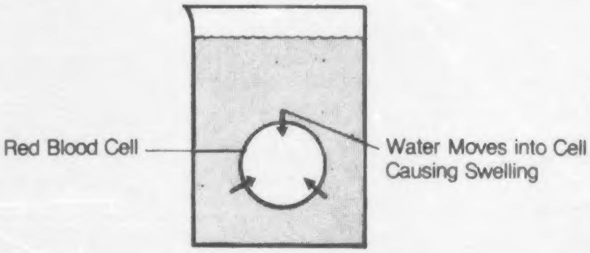


**Figure 5.** **Hypotonic Solution**

## A Closer Look at the Electrolytes

Each electrolyte plays a specific role in the body. It is important to know something about the characteristics of each because you will be dealing with patients who have electrolyte imbalances, and you will be administering solutions with different electrolyte concentrations. The principal cations are sodium, potassium, calcium, and magnesium. The principal anions are chloride and bicarbonate. Sodium ($Na^+$) is the most prevalent extracellular cation; through its osmotic force, it plays a major role in regulating water distribution throughout the body. As a general rule, *water follows sodium.* Therefore, when the body loses sodium—for example, after a patient takes a diuretic—water is lost with it. Similarly, when sodium is retained, water is retained also. For instance, when a person eats a bag of potato chips, he takes in a large amount of common salt. Because the sodium is absorbed from the intestines, the body responds by holding water, temporarily reducing urine output.

In normal individuals, the kidneys and other regulatory mechanisms soon straighten things out, and the kidneys excrete sodium along with the retained water, maintaining a safe sodium level. However, patients with certain illnesses cannot excrete sodium so readily. A patient with congestive heart failure, for example, already has excess sodium and water; eating a bag of potato chips or receiving an infusion of electrolyte solution may be fatal, because it may cause the retention of so much water that the patient literally drowns in his or her own extracellular fluid.

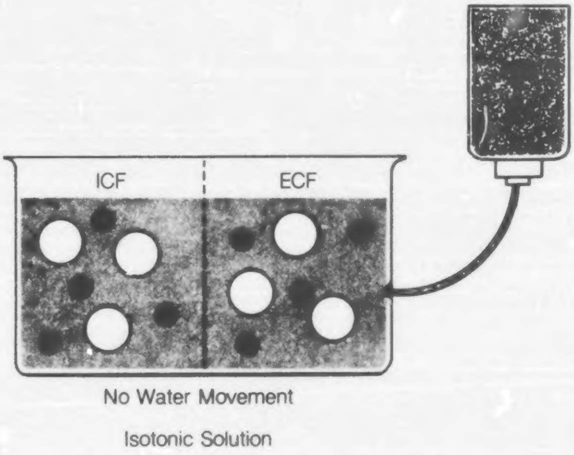


**Figure 4.** **Isotonic Solution**

Potassium ($K^+$) is the chief intracellular cation. It plays a critical role in conducting electrical impulses in nerves and muscles, including the heart, and is needed for nerve and muscle cell excitation (irritability). As an electrical impulse travels along a nerve or a muscle membrane, sodium ions enter the cell and potassium ions leave it.

If the potassium concentration in the body becomes too low or too high, cardiac arrhythmias may develop. High serum potassium (hyperkalemia) may occur in renal disease because the kidneys cannot excrete potassium. In such cases, potassium accumulates if the patient eats foods high in potassium (bananas, citrus fruits, tomatoes).

Trauma and acidosis also increase serum potassium levels. In trauma, potassium leaks out of damaged cells into the blood stream. This is rarely dangerous if kidney function is normal, because the kidneys rapidly excrete the excess potassium.

To understand why potassium accumulates in acidosis, it helps to be familiar with normal renal potassium excretion. When the kidney tubule reabsorbs sodium, it may excrete either hydrogen ions or potassium. In acidosis, the tubule preferentially excretes hydrogen ions to raise the serum pH toward normal—that is, to correct the acid-base balance in the body. (The acid-base balance is explained in the next section.) Potassium is retained in the body and accumulates in the blood stream.

Cardiovascular signs of hyperkalemia first appear on the electrocardiogram (EKG). (For a discussion of the normal EKG, see Module VI.) T-waves become high and peaked; QRS complexes widen; and S-T segments become depressed. If potassium levels rise still higher, T-waves disappear, heart block occurs, and the heart may stop completely (asystole).

Decreased serum potassium is called hypokalemia. (Hypokalemia occurs when there is increased potassium excretion due to either diuretics or alkalosis.) Diuretics greatly increase the number of sodium ions in the renal tubular lumen. As the tubular cells reabsorb part of these sodium ions, they excrete potassium ions into the urine, the body loses potassium, and hypokalemia may occur.

Alkalosis produces hypokalemia because renal tubular cells compensate by conserving hydrogen ions to lower the pH toward normal. The tubular cells excrete potassium instead of hydrogen ions when they reabsorb sodium. This lowers serum potassium levels.

Hypokalemia weakens skeletal, smooth, and cardiac muscle. Normal skeletal muscle reflexes disappear and gastrointestinal smooth muscle stops contracting.

Hypokalemia also produces characteristic EKG changes. Voltages of all EKG waves decrease, and T-waves flatten. S–T segments also become depressed. Other cardiac changes include cardiac arrhythmias and increased sensitivity to digitalis.

Calcium ($Ca^{++}$), which is derived largely from milk products and meat in the diet, is a versatile cation, useful particularly in bone development, blood clotting, and neuromuscular activity. Calcium ions are needed for normal muscle contraction. When a nerve stimulates a muscle cell, calcium ions flow out of stores within the muscle cell. These ions then bind to the contractile protein, actomyosin, and muscle contraction begins.

Calcium is found in the blood in both charged ($Ca^{++}$) and uncharged forms. Because only the charged form takes part in muscular contraction, changes in the relative amounts of charged and uncharged calcium alter muscle contraction, even when the total amount of calcium remains unchanged. Acidosis increases the amount of charged calcium; alkalosis decreases the amount of charged calcium. The amount of charged calcium in the blood also decreases in pancreatitis and renal disease.

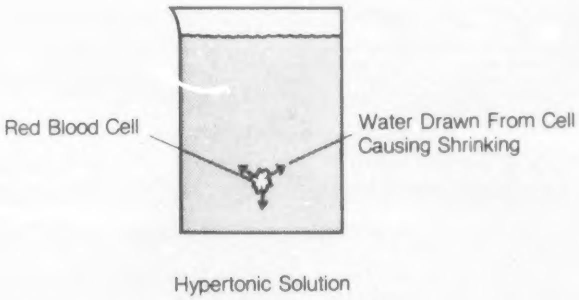


**Figure 6. Hypertonic Solution**

Low serum calcium (hypocalcemia) produces numbness and tingling around the mouth and in the fingers and toes. In addition, skeletal muscle reflexes become hyperactive (a condition called tetany), and skeletal and abdominal muscles cramp. Convulsions may occur. Cardiac changes are seen on the EKG as lengthened Q-T intervals.

High serum calcium (hypercalcemia) produces fatigue, weakness, nausea, and vomiting; loss of appetite; and weight loss. As serum calcium levels rise higher, the patient becomes drowsy, then unconscious, and finally comatose.

Hypercalcemia is most frequently seen in patients who have bone cancer or tumors of the parathyroid glands. These growths increase serum calcium by releasing calcium from the bones into the blood stream.

Magnesium ($Mg^{++}$), which is found in many foods, plays an important role as a coenzyme in protein and carbohydrate metabolism. It also acts in a manner similar to calcium to help control neuromuscular irritability.

Chloride ($Cl^-$), one of the principal anions, combines with sodium and thus is found primarily in the extracellular fluid. It participates indirectly in maintaining acid-base balance. Since sodium also binds a second anion, bicarbonate, there is a reciprocal relationship between chloride and bicarbonate concentrations in the extracellular fluid.

Bicarbonate ($HCO_3^-$) is the chief buffer in the body; as such, it plays a major role in maintaining acid-base balance. Other anions include phosphate ($HPO_4^-$), which is important in cell metabolism; organic acids such as lactic acids; and certain proteins. Plasma proteins play a particularly important role in maintaining vascular volume. Because they are large molecules, they stay within the vascular space and contribute to the osmotic "pull" of water from the interstitial fluid into the capillaries.

Table 3.1 presents normal electrolyte concentrations in the interstitial and intracellular fluids.

## Acid-Base Balance

Acid-base balance refers to regulation of the concentration of hydrogen ions ($H^+$) in body fluids. The body must keep its hydrogen-ion concentration within strict limits to maintain normal cell function. Even slight changes from the normal concentration disturb vital chemical reactions. The term "pH" is used to express the hydrogen-ion concentration of a fluid. The pH equals the negative log of the hydrogen-ion concentration:

where
$H^+$ = hydrogen-ion concentration

Expressing this in another way, the pH equals the

**Table 3.1.—Normal Electrolyte Concentrations**

(mEq per liter)

| Electrolyte | Serum | Interstitial Fluid | Intracellular Fluid |
|---|---|---|---|
| Sodium | 135–150 | 145 | 10 |
| Potassium | 3.5–5.2 | 4 | 160 |
| Calcium | 8–10 | 5 | 2 |
| Chloride | 95–110 | 114 | 3 |
| Bicarbonate | 21.5–28.5 | 31 | 10 |
| Phosphate | 2–4 | 2 | 100 |
| Proteins | 16 | 1 | 65 |

negative of the exponent in the following sample equation:

$$H^+ = 10^{(-7)\text{------exponent}}$$

Therefore, $pH = -(-7) = 7$ in this equation.

At a pH of 7, a solution is neutral. A fluid with a pH below 7 has an increased concentration of hydrogen ions and is called acid; a fluid with a pH above 7 has a decreased concentration of hydrogen ions and is called alkaline, or basic.

The body maintains a slightly alkaline pH; the normal pH range in the extracellular fluid is 7.35 to 7.45. A pH above 7.45 (decreased hydrogen-ion concentration) is considered alkalosis. A pH below 7.35 (increased hydrogen-ion concentration) indicates acidosis.

The extreme limits of pH compatible with life are about 6.9 on the acid side and 7.8 on the alkaline side.

| pH | Hydrogen Ions | Condition |
|---|---|---|
| Above 7.45 | Decreased | Alkalosis. |
| 7.35–7.45 | | Normal. |
| Below 7.35 | Increased | Acidosis. |

Metabolic processes usually produce excess acid, which the body must get rid of to maintain the acid-base balance, that is, to keep the pH within the normal range. For this purpose, the body has three principal processes or systems:

- The buffer system
- The respiratory system
- The renal system

The buffer system is the fastest-acting of the three defense mechanisms, responding within a fraction of a second to prevent large shifts in hydrogen-ion concentration. A buffer may be regarded as a chemical "sponge" that soaks up hydrogen ions when they are overabundant and releases them when their concentration becomes too low.

The most important kind of buffer system is the carbonate system, which consists of a mixture of carbonic acid ($H_2CO_3^-$) and bicarbonate ($HCO_3^-$) in a normal ratio of 1:20 (see Fig. 3.7). Carbonic acid is a weak acid that constantly breaks down into water ($H_2O$) and carbon dioxide ($CO_2$):

$$H_2CO_3 \longrightarrow H_2O + CO_2$$

or into hydrogen ions and bicarbonate ions:

$$H_2CO_3 \longrightarrow H^+ + HCO_3$$

Thus, carbonic acid is in equilibrium with both carbon dioxide and bicarbonate:

$$H_2O + CO_2 \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

There is an equation, called the Henderson-Hasselbalch equation, which is used to calculate the pH of mixtures of weak acids and their salts. For the carbonate system, this equation reads

$$pH = 6.1 + \log \frac{HCO_3^-}{H_2CO_3}$$

where

$HCO_3^-$ = bicarbonate concentration
$H_2CO_3$ = carbonic-acid concentration.

In the body, the normal ratio of bicarbonate to carbonic-acid concentration is 20:1. Inserting this value into the Henderson-Hasselbalch equation gives:

$$pH = 6.1 + \log \frac{20}{1} \qquad \frac{20}{1} = 20 \qquad \log 20 = 1.3$$

Therefore, $pH = 6.1 + 1.3 = 7.4$, the normal body pH. From the Henderson-Hasselbalch equation, it can be seen that increases in bicarbonate-ion concentration increase

$$\log \frac{HCO_3}{H_2CO_3}$$

and therefore raised pH (make the blood more alkaline).

In contrast, lowered bicarbonate levels decreased pH (make the blood more acidic) by decreasing

$$\log \frac{HCO_3^-}{H_2CO_3}$$

The effects of increased and decreased carbonic-acid levels can also be predicted from the Henderson-Hasselbalch equation. Increased carbonic acid concentration decreases

$$\log \frac{HCO_3}{H_2CO_3}$$

and therefore decreases pH. In contrast, decreased carbonic acid concentration increases

$$\log \frac{HCO_3^-}{H_2CO_3}$$

and thus increases pH.

The carbonate buffer system may also be examined nonmathematically. The direction in which the reaction

$$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

proceeds depends on which molecules are present in excess. For example, if carbon dioxide is added to the system (as in hypoventilation, with carbon dioxide retention), it combines with water to form more carbonic acid. The reaction will proceed to the right, in an attempt to rebalance the system:

$$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

As a result, the fluid becomes slightly more acid. It is prevented from becoming extremely acid because part of the carbonic acid produced dissociates into bicarbonate.

On the other hand, if hydrogen ions are added to the system, as in diabetic ketoacidosis where excess acids are accumulated, they combine with bicarbonate to form more carbonic acid. In this case, part of the carbonic acid dissociates into carbon dioxide and water:

$$-HCO_3 + H^+ \longrightarrow H_2CO_3 \longrightarrow H_2 + CO_2$$

The other two principal mechanisms for regulating the acid-base balance, the respiratory system and the renal system, eliminate the products of these reactions. The lungs eliminate carbon dioxide, and the kidneys eliminate bicarbonate.

The respiratory system acts as a backup system in acid-base regulation. The respiratory mechanism is slower than the buffer mechanism and takes 1 to 3 minutes to become effective.

When blood levels of carbon dioxide or hydrogen ions increase above normal, the respiratory centers of the brain are stimulated and increase the rate and depth of respiration. This increases the rate at which the lungs exhale carbon dioxide. The carbon dioxide concentration in the extracellular fluid falls, and there is less carbon dioxide available to form carbonic acid. As carbon-dioxide and hydrogen-ion concentrations return toward normal, stimulation of the respiratory center decreases, and the rate and depth of respiration return toward normal.

The renal system deals relatively slowly with pH changes and requires hours to days before it becomes effective. Therefore, renal regulation is important mainly in long-term maintenance of the acid-base balance.

The kidneys regulate pH by excreting excess hydrogen or bicarbonate ions. If the pH of the extracellular fluid falls (i.e., if the hydrogen-ion concentration increases), the kidneys eliminate more hydrogen ions. If the pH of the extracellular fluid rises, the kidneys eliminate more bicarbonate ions to restore the balance.

As was mentioned earlier in this chapter, the kidney may excrete either hydrogen or potassium ions when it reabsorbs sodium. When hydrogen-ion excretion increases to compensate for acidosis, potassium excretion decreases, and potassium accumulates in the blood stream.

In contrast, when the kidney retains hydrogen ions to compensate for alkalosis, potassium excretion increases and the serum potassium level decreases.

The operations of the acid-base balance have clinical applications. Normally, as was mentioned, the bicarbonate and carbonic acid in the extracellular fluid are in balance. However, there are several clinical conditions in which this balance is disrupted. They are respiratory acidosis and alkalosis and metabolic acidosis and alkalosis.

Any condition that hampers ventilation may result in carbon dioxide retention, or respiratory acidosis. The retained carbon dioxide combines with water to form carbonic acid ($H_2CO_3$), which partly dissociates into hydrogen ions ($H^+$) and bicarbonate ($HCO_3$

$$H_2CO_3 \longrightarrow CO_2 + H_2O \longrightarrow H^+ + HCO_3^-$$

Once again, the effect of increased carbonic acid on the pH can be determined from the Henderson-Hasselbalch equation. For example, if the carbonic-acid concentration becomes 1½ times greater, the ratio of bicarbonate to carbonic acid changes from 20:1 to 20:1.5. Inserting this into the Henderson-Hasselbalch equation:

$$pH = 6.1 + \log \frac{HCO_3}{H_2CO_3} = 6.1 + \log \frac{20}{1.5}$$

$$\frac{20}{1.5} = 13$$

$$\log 13 = 1.1$$

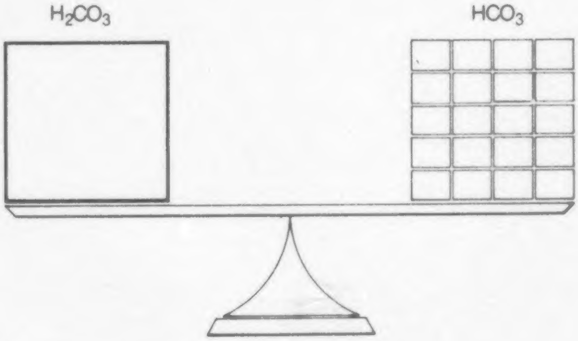


Figure 7. The Carbonate System

Therefore, $pH = 6.1 + 1.1 = 7.2$. (Remember that a pH below 7.35 indicates acidosis.) Because the pH falls when carbon dioxide accumulates, the kidney must conserve potassium ions in order to excrete hydrogen ions. This means that serum potassium ($K^+$) rises in respiratory acidosis.

To treat respiratory acidosis, the underlying respiratory problem must be corrected and ventilation must be improved. Treatment of respiratory problems is described in Module V.

Any condition leading to hyperventilation increases the expiration of carbon dioxide and reduces the carbonic-acid level. This leads to an increase in pH, and respiratory alkalosis develops. This occurs, for example, when a patient hyperventilates and blows off more carbon dioxide than usual. As a result, carbonic acid dissociates into carbon dioxide and water to replace part of the exhaled carbon dioxide:

$$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

Similarly, hydrogen ions and bicarbonate recombine to replace part of the dissociated carbonic acid.

The effect of lowered carbonic acid on pH can be determined from the Henderson-Hasselbalch equation. For example, if the carbonic-acid concentration becomes half as large, the ratio of bicarbonate to carbonic acid changes from 20:1 to 20:0.5. Inserting this into the equation:

$$pH = 6.1 + \log \frac{20}{0.5}$$

$$\frac{20}{0.5} = 40$$

$$\log 40 = 1.6$$

Therefore, $pH = 6.1 + 1.6 = 7.7$. (Recall that a pH above 7.45 indicates alkalosis.)

Although the problem exists in the respiratory system, it is the kidneys that compensate, as in acidosis. In alkalosis, however, the kidneys excrete bicarbonate and potassium ions and retain hydrogen ions. This returns the pH toward normal.

Theoretically, respiratory alkalosis could be treated by administering carbon dioxide to the patient. This is in fact the principle behind treatment of hyperventilation: The patient is asked to breathe into a paper bag, so that he or she rebreathes the exhaled carbon dioxide. In this way, carbon dioxide levels in the blood are restored to normal.

Metabolic acidosis occurs when excess acid is produced by the body, as in diabetic ketoacidosis. It may also occur during intoxication with substances such as salicylates and methanol. The acid, which is poured into the extracellular fluid, combines with the bicarbonate buffer to form carbonic acid. Thus, there is both an increase in acid and a decrease in base available to neutralize it.

The Henderson-Hasselbalch equation is again useful in determining the effects of increased carbonic acid and decreased bicarbonate on pH. For example, if the carbonic acid concentration increases by 25 percent and the bicarbonate concentration decreases by 25 percent, the ratio becomes

$$\frac{HCO_3^-}{H_2CO_3} = \frac{15}{1.25} = 12$$

Inserting this into the equation

$$pH = 6.1 + \log 12$$

$$\log 12 = 1.1$$

$$pH = 6.1 + 1.1 = 7.2$$

Immediate compensation for metabolic acidosis comes from the lungs. As has been pointed out, a fall in pH stimulates the respiratory center of the brain to increase the rate and depth of respiration. As this occurs, more carbon dioxide is blown off and the carbonic-acid concentration falls.

Over the long term, the kidneys excrete more hydrogen ions, again compensating for the excess acid. When the kidneys excrete hydrogen ions in metabolic acidosis, they conserve bicarbonate and potassium ions.

To treat metabolic acidosis, the underlying metabolic problem must be corrected. This, however, takes time, so when metabolic acidosis is severe enough to prevent normal cardiac function, you should administer bicarbonate to restore the pH toward normal rapidly.

Metabolic alkalosis occurs when serum bicarbonate levels rise. This may happen when the patient takes large amounts of sodium bicarbonate as an antacid, when a physician or paramedic administers excessive sodium bicarbonate intravenously to a patient, or when a patient loses excessive amounts of acids, chlorides, and potassium in vomiting or diarrhea.

The bicarbonate combines with hydrogen ions to form carbonic acid:

$$CO_2 + H_2O \longrightarrow H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

Therefore, there are increased numbers of bicarbonate ions and decreased numbers of hydrogen ions, and the pH rises.

The effects of increased bicarbonate on pH can also be determined using the Henderson-Hasselbalch equation. If, for example, bicarbonate ion concentration doubles, the ratio of bicarbonate to carbonic acid changes from 20:1 to 40:1. Inserting this into the equation:

$$pH = 6.1 + \log \frac{40}{1}$$

$$\log \frac{40}{1} = \log 40 = 1.6$$

Therefore, $pH = 6.1 + 1.6 = 7.6$

The lungs attempt to compensate for metabolic alkalosis by retaining carbon dioxide, so breathing becomes slower and shallower. The ability of the lungs to compensate for metabolic alkalosis is limited, however, because the body must continuously replenish its oxygen supply through breathing. Therefore, most compensation for metabolic alkalosis occurs in the kidneys. The kidneys excrete bicarbonate and retain hydrogen ions. To retain hydrogen ions, the kidneys must excrete potassium, so serum potassium levels fall during metabolic alkalosis.

Patients with chronic metabolic alkalosis become dehydrated and hypokalemic. Treatment of alkalosis in these patients includes restoring blood volume and replacing potassium.

Table 3.2 summarizes the derangements of the acid-base balance discussed in this section.

## Unit 2. Blood and its Components

Blood is the circulating fluid of the cardiovascular system, and it performs many functions:

- Respiratory function. Blood carries oxygen from the lungs to the tissues and carbon dioxide from the tissues to the lungs.
- Nutritional function. Blood carries nutrients (glucose, proteins, fats).
- Excretory function. Blood carries the waste products of metabolism from the cells where they are produced to excretory organs.
- Regulatory function. Blood carries hormones to their target organs and transmits excess internal heat to the surface of the body to be dissipated.
- Defensive function. Blood carries defensive cells and antibodies throughout the body.

### Composition of Blood

The blood consists of formed elements, or cells, and the fluid, plasma, in which the cells are suspended. The formed elements are red and white blood cells and platelets. Red blood cells (RBC's), or erythrocytes, give blood its characteristic color. In the normal adult, RBC's compose 40 to 45 percent of the circulating blood volume. The hematocrit gives the percentage of whole blood composed of RBC's.

With severe blood loss or chronic anemia, the hematocrit may fall much lower than 45 percent. In contrast, dehydration increases the hematocrit, because it decreases the plasma volume without changing the number of RBC's. The same number of blood cells therefore make up a larger percentage of the whole blood.

**Table 3.2**
**Derangements of the Acid-Base Balance**

| Condition | pH | $H_2CO_3$ | $HCO_3$ | Compensation | Examples |
|---|---|---|---|---|---|
| Respiratory acidosis | ↓ | ↑ | ...... | Kidneys excrete $H^+$, retain $HCO_3^-$ | Respirations depressed by drugs, trauma, emphysema, chronic bronchitis |
| Respiratory alkalosis | ↑ | ↓ | ...... | Kidneys excrete $HCO_3^-$, retain $H^+$ | Hyperventilation |
| Metabolic acidosis | ↓ | ↑ | ↓ | Lungs exhale more $CO_2$; kidneys excrete $H^+$ and retain $HCO_3^-$ | Diabetic ketoacidosis; lactic acidosis in shock |
| Metabolic alkalosis | ↑ | ...... | ↓ | Lungs retain $CO_2$; kidneys excrete $HCO_3^-$ and retain $H^+$ | Ingestion of sodium bicarbonate; severe vomiting |

The most important constituent of the RBC is hemoglobin, an iron-containing protein, which is able to unite with oxygen. When it does so, it becomes bright red, the color associated with arterial blood. When hemoglobin releases oxygen, its color returns to the darker blue-red characteristic of venous blood.

Human blood contains about 15 grams (g) of hemoglobin per 100 ml of blood. If more than 5 g of hemoglobin per 100 ml becomes desaturated—that is, not combined with oxygen—the blood assumes a bluish color, which is reflected in the skin as cyanosis (a bluish color). It is important to note, however, that cyanosis is not a reliable indication of tissue oxygenation, because tissue oxygenation depends on the amount of hemoglobin that is saturated with oxygen. Cyanosis is no indication of this amount.

To illustrate this point, consider first a patient with a low hemoglobin level, for example, an anemic patient. If this patient's hemoglobin is 6 g/100 ml, and 3 g/100 ml are not combined with oxygen, only 3 g/100 ml hemoglobin will be saturated with oxygen. This will not oxygenate the tissues adequately, but the patient will not be cyanotic, because less than 5 g/100 ml hemoglobin are unsaturated.

In contrast, a patient with a high hemoglobin concentration may be cyanotic in spite of adequate tissue oxygenation. If, for example, he or she has a hemoglobin level of 18 g/100 ml, and 5 g/100 ml are not saturated with oxygen, the patient will appear cyanotic. However, 13 g/100 ml will be saturated hemoglobin, which will be adequate for tissue oxygenation.

White blood cells (WBC's), or leukocytes, serve a defensive function by engulfing infectious organisms and producing antibodies. A normal adult has 3,000 to 11,000 WBC's per milliliter of blood. During an infection, WBC's multiply to combat the infecting organisms. This increase in WBC count is referred to as leukocytosis.

Platelets, or thrombocytes, participate in blood clotting and help seal leaks in injured vessels. The normal adult has 150,000 to 400,000 platelets per milliliter of blood. When platelet counts fall below 50,000 to 60,000 per milliliter, the individual may bleed uncontrollably.

Plasma makes up about 55 percent of the blood by volume. It is a complex fluid containing proteins (clotting factors, hormones, enzymes, antibodies), inorganic salts, nutrient and waste materials, and gases in solution. Because plasma is high in protein, plasma derivatives such as albuminate or Plasmatein are valuable replacement solutions for patients with significant blood loss.

Serum is the fluid part of the clotted blood. It is similar to plasma but lacks fibrinogen (a plasma-clotting factor), because fibrinogen forms part of the clot. Clinical laboratories use serum, rather than plasma, to determine blood electrolyte concentrations.

## Blood Typing

The plasma of one person may contain antibodies that would cause the RBC's of another individual to clump together (agglutinate). Such bloods are termed "incompatible," and if they are mixed together by a transfusion, serious and even fatal reactions may occur. The safe administration of blood from a donor to a patient requires that the blood of both donor and recipient be typed and cross-matched to insure that the patient receives only blood that is compatible with his or her own.

The compatibility of blood is based on the presence or absence of certain antigens (substances which cause antibodies to form) on the surface of the RBC's and the presence or absence of antibodies to these antigens in the plasma. RBC antigens are large carbohydrate-protein complexes on the red cell surface. Individuals who lack these complexes on their RBC's possess or are able to form antibodies to them when an antigen is introduced into the body.

As was discussed in Module II, antibodies are large serum proteins that are formed by plasma cells (derivatives of lymphocytes) in response to a foreign substance (antigen). Antibodies are specially shaped to combine with the corresponding antigen. The combination of the antigen with the antibody helps the body rid itself of the antigen. Antibodies are named according to the antigen that led to their formation or with which they combine. For example, anti-A means antibody to antigen A, and anti-B refers to the antibody to antigen B. The major blood group classification is the ABO system; the ABO blood types are named according to the antigen present on the RBC's (see Table 3.3).

From Table 3.3, it can be seen that an individual with type A blood should not receive a transfusion from a type B donor, since the donor's RBC's would be quickly agglutinated by the recipient's anti-B antibody. The type A individual could, however, receive blood either from another type A subject or from a type O donor, whose RBC's have no antigens. Because of this property of the RBC's, the type O individual is sometimes known as the "universal donor." The type AB individual, on the other hand, has no antibodies in the plasma, and can receive blood from any other group. Persons of blood type AB are therefore called "universal recipients."

**Table 3.3.—Blood Antigens and Antibodies**

| Blood Type | Antigen Present on RBC | Antibody Present in Serum |
|---|---|---|
| A | A | Anti-B |
| B | B | Anti-A |
| AB | A and B | None |
| O | None | Anti-A and anti-B |

These relationships may be diagramed as follows:

| Cells of Donor | Reaction to Serum of Recipient | | | |
|---|---|---|---|---|
| | *O* | *A* | *B* | *AB* |
| O | – | – | – | – |
| A | + | – | + | – |
| B | + | + | – | – |
| AB | + | + | + | – |

Note: + = agglutination; – = nonagglutination.

The red cells of about 85 percent of the population also contain an antigen known as the Rh factor (taken from "Rhesus," the type of monkey in which research on this factor has been conducted). When the red cells contain this substance, the blood is called "Rh positive"; when the red cells lack the antigen, the blood is termed "Rh negative." In contrast to anti-A and anti-B antibodies, which occur naturally, antibodies (agglutinins) to the Rh antigen do not occur naturally. Instead, they develop in Rh negative individuals who receive a transfusion of Rh positive blood. Once sensitized, the Rh negative individual may have a severe or fatal reaction if he or she later receives another transfusion of Rh positive blood.

A similar sensitization may occur in an Rh negative woman who is carrying an Rh positive fetus. When Rh positive blood from the fetus crosses the placenta into the mother's circulation, she may develop antibodies against the Rh factor. In later pregnancies, if she again carries an Rh positive fetus, the agglutinins in her blood may destroy the fetal RBC's.

## Blood Preparations, Derivatives, and Substitutes

While whole blood can be stored for 2 to 3 weeks, platelets and some clotting factors deteriorate within 24 hours after the blood is drawn. Therefore, if a patient receives a large amount of banked blood, his clotting ability may be impaired. For this reason, a patient who receives massive transfusions should be given a few units of fresh whole blood or platelets and fresh-frozen plasma (which contains clotting factors) along with the banked blood.

Whole blood may be used to restore circulating blood volume in patients with acute loss of whole blood, as in cases of trauma or massive hemorrhage. In these cases, whole blood is given to maintain a hematocrit of 30 to 35 percent. (Recall that the normal hematocrit is 45 percent.)

Whole blood is less suitable for treatment of shock resulting from loss of plasma (e.g., burns) or extracellular fluid (e.g., massive diarrhea). Whenever it is given, whole blood should be administered through a special infusion set that filters out particles.

Packed RBC's are obtained by separating the red cells from the plasma in which they are suspended; they can be stored from 2 to 3 weeks. Like whole blood, packed red cells must be typed and cross-matched before administration. Packed red cells are used to improve the oxygen-carrying capacity of the blood and to treat anemia rapidly. Packed red cells are also useful in cardiac patients with hemorrhage, because whole blood replacement can create a volume overload in these patients.

Plasma, obtained by removing the red cells from whole blood, is available in several forms: liquid, frozen, and vacuum-dried. Unlike whole blood, plasma does not need to be typed and cross-matched. Because plasma, like whole blood and untreated blood derivatives, carries a significant hepatitis risk, it is rarely used to restore blood volume in hypovolemic shock (shock caused by diminished blood volume).

The fresh-frozen form of plasma does need to be typed, but need not be cross-matched. It contains active clotting factors and is used in patients who have clotting-factor deficiencies.

Solutions containing large carbohydrate or protein molecules are available as plasma substitutes. Because these solutions contain large molecules, which have difficulty crossing membranes, they remain in the blood stream following an intravenous (IV) infusion. They are used to restore blood volume in the emergency treatment of shock. These solutions are used more frequently than plasma because they do not require typing, they can be carried in the emergency vehicle, and they do not carry a hepatitis risk.

Among the plasma substitutes, or "volume expanders," available are dextran and plasma derivatives. Dextran contains large carbohydrate molecules that stay in the vascular space because they cannot cross membranes. Dextran coats RBC's and can therefore interfere with blood cross-matching. For this reason, blood for type- and cross-matching should always be taken before dextran is given. Dextran also causes clotting problems; therefore, no more than 1 [illegible] should be given. Low-molecular-weight dextran crosses the kidney glomerulus (the part of the kidney that filters out waste materials) and may clog the renal tubules and should never be used. Because of all these problems, dextran is not often used to expand blood volume.

Instead, plasma derivatives such as albuminate and Plasmatein are used. These derivatives are obtained by separating plasma proteins from pooled plasma samples, heating the plasma proteins to destroy the hepatitis virus, and then resuspending them in a sodium solution. In addition to plasma proteins, albuminate and Plasmatein can contain about 145 mEq per liter sodium, 100 mEq per liter chloride, and 2 mEq per liter potassium. These solutions are preferable to dextran, because they do not interfere with blood clotting or blood typing and do not injure kidney tubules.

Crystalloids are non-protein-containing fluids, that is, noncolloids. Their effects in restoring volume in shock are transitory, because the fluid rapidly equilibrates across the capillary walls into the tissues. Therefore, when crystalloid solutions are used to treat hemorrhagic shock, the volume administered needs to be two or three times the volume of the blood lost. Crystalloids are most useful in situations where only salt and water have been lost, for example, in dehydration.

The crystalloids most commonly used are normal saline and lactated Ringer's solution. Normal saline is simply sodium chloride (NaCl) in water at isotonic concentration. Lactated Ringer's solution contains sodium chloride, potassium, calcium, and lactate. Lactate serves as a buffer, because the liver breaks it down into bicarbonate.

Other intravenous solutions commercially available include D5W (5 percent dextrose in water), D5 1/2NS (5 percent dextrose in 0.45 percent NaCl), and D5 1/4NS (5 percent dextrose in 0.22 percent NaCl). None of these solutions should be used to restore blood volume in hypovolemic shock. The dextrose (glucose) in these solutions rapidly enters the cells by active transport. The remaining solution is hypotonic, so the excess water follows dextrose out of the blood stream until the blood and extravascular spaces become isotonic. The result is that D5W does not expand the blood volume at all.

D5 1/2NS and D5 1/4NS do expand the blood volume, but only one-half and one-fourth as much, respectively, as equal volumes of normal saline. Also, D5 1/2NS and D5 1/4NS will dilute the body fluids if infused in large quantities. They should not be used to expand blood volume.

D5W is used to keep open an IV line for giving medications in heart patients. D5 1/2NS and D5 1/4NS are used to replace normal daily losses in hospitalized patients who are unable to eat. Electrolyte compositions of common IV solutions are shown in Table 3.4.

Resuscitation following fluid losses usually begins with normal saline or lactated Ringer's solutions, which are readily available. At the beginning of fluid resuscitation, blood is drawn for typing, cross-matching, and determination of hematocrit. When whole blood becomes available, it is given to maintain a hematocrit greater than 30 to 35 percent.

Resuscitation with crystalloid solutions and whole blood seldom dilutes plasma proteins enough to require plasma replacement in hemorrhagic shock. However, if plasma protein levels are found to be inadequate, albuminate or Plasmatein may be infused to restore plasma osmotic pressure.

**Table 3.4.—Compositions of Intravenous Fluids**

| Solution | Ion | | | | |
|---|---|---|---|---|---|
| | $Na^+$ | $K^+$ | $Ca^+$ | $Cl^-$ | Lactate |
| Lactated Ringer's | 130 | 4 | 2.7 | 109 | 28 |
| Normal saline | 154 | | | 154 | |
| 1/6M sodium lactate | 167 | | | | 167 |
| 1/2NS | 77 | | | 77 | |
| 1/4NS | 38 | | | 77 | |

When 2 to 3 1 of crystalloid do not adequately restore blood volume and whole blood is not available, albuminate and Plasmatein, rather than additional crystalloid, should be given to restore blood volume. Additional crystalloid would greatly expand the extravascular spaces when it later equilibrated across membranes. Plasma proteins are less able to cross membranes and therefore will not expand the extravascular spaces as much. Plasma derivatives may also be given to maintain plasma osmotic pressure, if needed.

In hypovolemic shock resulting from plasma loss or dehydration, resuscitation with normal saline or lactated Ringer's may be adequate. But plasma derivatives may be added in hypovolemic shock due to plasma loss, if they are needed to restore osmotic pressure.

## Blood Transfusion

While blood transfusion is unquestionably life-saving in many cases, it does carry certain risks and may cause the following complications:

- Fever. This is the most common transfusion reaction. It may be caused by a sensitivity to the donor WBC's or by contamination of transfusion equipment.
- Allergic reactions. These complications are relatively common and are usually shown by hives (urticaria).
- Viral hepatitis. At least 0.5 percent of patients receiving two or more units of blood will develop clinical signs of viral hepatitis. Pooled plasma transfusions increase this risk.
- Hemolytic reactions. Breakdown of RBC's (hemolytic reactions) due to incompatibility are very serious. Such reactions usually appear by the time 50 ml of blood has been infused. Common symptoms include severe low back pain, throbbing headache, shortness of breath (dyspnea), restlessness, anxiety, and pain beneath the breastbone (substernal pain). However, hemolytic reactions may occur with few symptoms at all, especially in the semiconscious or comatose patient.

On examination, the patient with a transfusion reaction will often show:

- Flushing of the face, followed by cyanosis
- Sweating (diaphoresis) and cold, clammy skin
- Abnormally slow heart beat (bradycardia), followed by rapid, thready pulse
- Distended neck veins
- Falling blood pressure

If you suspect a transfusion reaction for any reason, the transfusion should be stopped immediately. Do not wait for further symptoms to develop; follow the procedures outlined in the local blood bank manual.

Other complications a blood transfusion may cause are:

- Heart failure. Patients with borderline cardiac function may experience heart failure if they receive a volume overload during transfusion.
- Air embolism. Normal adults can tolerate as much as 200 ml of air introduced into the peripheral vein, but in critically ill patients as little as 10 ml of air may be fatal. The presence of air embolism is manifested by sudden shock with cyanosis, hypotension, rapid heart beat (tachycardia), and a diminished level of consciousness. If air embolism occurs, the administration tubing should be clamped immediately. The patient should then be placed in a left-lateral half-prone position with the head down. This prevents air from entering the coronary or cerebral arteries and thus prevents myocardial or cerebral infarction (cell death due to inadequate blood flow).

## Unit 3. Disorders of Hydration

The healthy body maintains a delicate balance between intake and output of fluids and electrolytes to insure that the internal environment remains constant in spite of changing intake and obligatory losses. The ill or injured person is often less able to maintain this balance, so excesses or deficiencies of fluids and body chemicals may occur.

Since you will be administering IV fluids, you need to know when parenteral fluids are needed, what kind of fluids should be used, and when IV fluids can be dangerous. Although verbal orders or protocols will largely govern the use of IV fluids in the field, you should know enough about IV therapy to question inappropriate orders and to function independently when radio communication fails.

The normal person loses approximately 2 to 2.5 l of fluids daily as urine and through the lungs and skin. These losses are replaced by fluid intake and by nutrients, which are partly converted to water when they are metabolized. In illness, overhydration or dehydration may occur.

### Dehydration

Abnormal losses of fluids and electrolytes may occur through the following mechanisms:

- Gastrointestinal losses, especially from vomiting and diarrhea
- Increased imperceptible (insensible) loss, due to fever, hyperventilation, or high environmental temperatures
- Increased sweating
- Increased urinary losses
- Internal losses ("third space" losses), such as occur in infection of the abdominal lining (peritonitis), pancreatitis, and obstruction of the small intestine (ileus)
- Plasma losses, from burns, drains, granulating wounds

In each case, the fluid lost has a unique electrolyte composition, so long-term therapy is aimed specifically at restoring deficient electrolytes. For purposes of treatment in the field, however, all excessive fluid losses can be considered to lead to dehydration.

Symptoms of dehydration include loss of appetite, nausea, vomiting, and sometimes fainting on standing up (postural syncope). Upon physical examination, the dehydrated patient is found to have poor skin turgor (the skin over the forehead or sternum will "tent" when pinched); a shrunken, furrowed tongue; and sunken eyes. The pulse is weak and rapid, and raising the patient from the supine to the sitting position may make the patient feel faint. When fluid and electrolyte depletion are severe, shock and coma may occur.

The dehydrated patient needs fluid and electrolyte replacement and should, therefore, be given an IV of normal saline or Ringer's solution at a rate around 100 to 200 ml per hour in an adult; the exact rate depends on the circumstances. The patient should be kept flat to optimize circulation to the brain. Treatment of associated shock will be described in a later section.

### Overhydration

Overhydration refers to an overall increase in total body salt and water, as in congestive heart failure or some cases of cirrhosis of the liver. This type of autogenous overhydrated patient—that is, a patient whose excess fluid originates within his or her body—is dealt with in the field. The cardinal sign of overhydration is edema. However, edema does not become clinically apparent until 5 to 10 pounds of excess fluid is retained. Patients with heart disease may also manifest circulatory overload in the form of left heart failure, with shortness of breath (dyspnea), rales, and other signs of pulmonary edema.

Obviously, these patients do not need any more fluid. Indeed, therapy is directed at ridding the body of excess fluids through salt restriction, diuretics, and occasionally, even blood-letting (phlebotomy). Therefore, if an IV must be started on an already overhydrated patient to keep a route open for intravenous medications, you should (1) give as little fluid as possible (use a microdrip and regulate the rate to "keep open") and (2) give a type of fluid that will not stay in the vascular space, that is, D5W. You should avoid infusing electrolyte solutions into these patients.

## Unit 4. Shock

Shock occurs when the tissues or organs are inadequately supplied with oxygenated blood. Inadequate perfusion may be accompanied by decreased arterial blood pressure. Three factors are necessary to maintain normal perfusion: a functioning heart, or pump; adequate blood volume; and an intact vascular system capable of reflex changes in response to changes in blood pressure. Abnormalities in any one of these can produce shock.

Shock is classified into four major types: hypovolemic, cardiogenic, septic, and neurogenic. Hypovolemic shock results from blood loss. Cardiogenic shock results from pump failure. Septic and neurogenic shock result from abnormalities in the vascular system. Hypovolemic shock, the most common form, will be described in detail as a model for all four types of shock. Then, cardiogenic, septic, and neurogenic shock will be discussed separately and compared with hypovolemic shock.

### Hypovolemic Shock

Hypovolemic shock occurs whenever fluid is lost from the intravascular compartment. This loss may result from internal or external hemorrhage, burns, vomiting, diarrhea, excessive sweating, peritonitis, or pancreatitis. External hemorrhage is easily recognized as a source of blood loss. Internal hemorrhage, however, may be hidden.

Internal hemorrhage may occur into the thoracic or abdominal cavities following injury to the internal organs. Significant internal blood loss may also occur with bone fractures, especially fractures of the pelvic and long bones. Pelvic fractures with crush injury often tear associated blood vessels; they cause shock in 40 percent of patients. Fracture of one long bone typically results in loss of 500 to 1,000 ml of blood into the surrounding tissues; femoral-shaft fractures may produce blood losses of 1,000 to 2,000 ml.

There are multiple physiologic factors in the body's response to shock. When blood volume is lost, less blood returns to the heart from the great veins (decreased preload) and cardiac output decreases. This decrease in cardiac output is quickly identified by the pressure receptors (baroreceptors) in both the aortic arch and the carotid sinus, which send less frequent stimuli to the brain. The central response is an increase in the discharge from the sympathetic nervous system (norepinephrine) and from the adrenal gland (epinephrine). The increased concentration of these substances results in 1) increased peripheral resistance and 2) stronger and more rapid cardiac contractions. Both of these changes return the pressure at the baroreceptors toward normal limits. The detrimental result, however, is deprivation of circulation to some peripheral tissues such as skin, fat, and muscle.

In somewhat simplistic terms, when the fluid volume is down, the container contracts in size and the pump operates more strongly and rapidly. This provides improved perfusion of blood through the brain and lungs.

If the volume of blood lost is so great that these mechanisms can no longer adequately compensate, the arterial pressure remains depressed. As the body continues to increase peripheral resistance, more and more portions are deprived of blood flow. This accounts for the fact that when the arterial pressure drops below 80, a regular pulse can no longer be felt.

The decreased flow through the capillaries produces three detrimental effects:

1. The most important is the conversion of cellular metabolism from aerobic to anaerobic. This causes the cells to produce more lactic and pyruvic acid. This accumulates in the fluid surrounding the cells and is picked up by the vascular system when circulation in the capillaries returns. This cellular hypofusion is the one condition in shock that produces acidosis. The proper management of such a condition is not to load the patient with sodium bicarbonate but to return adequate circulation as rapidly as possible.

2. The second condition that develops on the cellular level affects the walls of the capillaries themselves. Ischemia and hypofusion that exist (or some other metabolic phenomenon not yet well understood) allows the interstices lining cells of the capillary to become more widely separated, so that the capillary walls are no longer able to contain the larger molecule intravascular components such as albumin. The passage of albumin through the capillary wall tends to equalize pressure inside and outside the capillary. This allows edema to develop. If edema develops in the lungs, the space between the pulmonary alveolus and the capillary is increased and oxygen transfer is compromised. This condition is known as adult respiratory distress syndrome.

3. The third condition, which has not been definitively demonstrated to produce problems, involves the red cells. As the red cells stagnate within the vessels, they clump together. As the circulation is reestablished, the clumps float freely back into the general circulation. These clots could lodge in the pulmonary circulation producing flow to those hearts affected.

These mechanisms compensate for blood losses of less than 1 l, or 20 percent of circulating blood volume. Blood losses over 1 l result in the accumulation of lactic acid in the tissues, because oxygen is not available to break down pyruvate. This accumulated lactic acid lowers pH. This relaxes precapillary arterioles, but not postcapillary venules. Increased blood pressure in the capillaries and increased capillary permeability permit blood to accumulate in the capillaries and to enter the extravascular space. This further decreases blood volume, and cells die because they do not receive enough oxygenated blood.

The signs and symptoms of hypovolemic shock are due to inadequate tissue oxygenation and the sympathetic nervous system's response to decreasing blood pressure. The patient in hypovolemic shock often appears to be simply confused and disoriented. He or she may look apprehensive or "scared." On physical examination, respirations are rapid and shallow, and the pulse fast and thready. Peripheral veins will be collapsed when you look for them to start an IV. The skin is usually cold, clammy, and pale. Diffuse mottling of the skin is common, and cyanosis may be present. Finally, the blood pressure may be falling. However, you should not rely on blood pressure to diagnose shock. Falling blood pressure is a late sign of shock and signals the collapse of all compensatory mechanisms. You should, therefore, learn to recognize earlier signs and treat shock early.

The classic appearance of a patient in shock was described by Billroth in 1870:

> The face becomes pale, lips blue, pulse is smaller, the temperature falls in the extremities, the patient is subject to fainting spells, nausea and vomiting, vision obscured; with continuous hemorrhage, the countenance grows waxey, the eyes dull, the body temperature is lower, the pulse small, thready, and very frequent, respiration is incomplete, the patient constantly grows more feeble and anxious; at last he remains unconscious and there is twitching of the arms and legs which is renewed at the slightest irritation and then death.

To estimate blood loss in the field, you should use the blood pressure and pulse. A systolic blood pressure less than 70 together with a pulse greater than 130 per minute implies at least a 40 percent loss of blood volume. (When the blood pressure cannot be obtained at the arm, this is a rough guide: If a femoral pulse is palpable, the systolic blood pressure is probably at least 60; if a carotid pulse is palpable, the systolic pressure is probably at least 70; and if a radial pulse is palpable, the systolic pressure probably exceeds 80 to 90 mm Hg.) It should be noted that the pulse and blood pressure should be evaluated to determine management.

To estimate blood loss from causes other than trauma, you may also use the postural test. This test should not be attempted in trauma victims because it can aggravate spinal injury. To perform a postural test, take the patient's pulse rate while he or she is lying down. Then have the patient sit up and quickly retake his pulse. If the pulse rate increases by more than 20 per minute when the patient sits up, there has been a blood loss of at least one unit (500 ml).

In managing hypovolemic shock, the goal is to maintain perfusion of the brain, coronary arteries, and kidneys with oxygenated blood. The best indication of brain perfusion is the patient's level of consciousness. If the patient is conscious and alert, the brain is adequately perfused. If the patient is confused, disoriented, or unconscious, brain perfusion is probably inadequate.

In a catheterized patient, kidney perfusion can be gauged by urine output. Adequately perfused kidneys put out at least 30 to 50 ml of urine per hour; poorly perfused kidneys put out less than 30 ml per hour. In general, in the field—where most patients will not have urinary catheters—you must rely on the patient's state of consciousness to evaluate perfusion of vital organs. This should be monitored as closely and accurately as blood pressure.

There are various mechanisms for classifying hemorrhagic shock. The method developed in the Advanced Trauma Life Support course is effective and simple. It is as follows:

Class 1 Hemorrhage—Minimal increase in pulse rate with normal blood pressure, respirations, and capillary blanch test. This represents a loss of about 15 percent of the total blood, or about 1,050 cc in a 70-kg male.

Class 2 Hemorrhage—The pulse rate is in excess of 120 with some excessively rapid breathing (tachypnea). The systolic pressure also drops. This represents a loss of 20 to 25 percent of blood volume, or about 1,000 or 1,250 cc.

Class 3 Hemorrhage—There is a loss of 30 to 35 percent of the circulating blood volume, representing in excess of three units of whole blood. This patient presents the classical clinical signs of hypovolemia, including significantly depressed blood pressure.

Class 4 Hemorrhage—There is a blood loss in excess of 2 l (four units). Blood pressure is in general nondetectable. Pulse is detectable only at the carotid, if at all. The part of the brain which receives and interprets sensations (the sensorium) will be depressed.

To treat hypovolemic shock, you should take the following steps.

I. Primary Survey

A. Evaluate and establish an airway, taking into consideration the possibility of a cervical spine fracture.

B. Assure that the patient's breathing and ventilation are adequate, carefully considering the possibility of tension pneumothorax, open pneumothorax, and large unstable flail segment.

C. Assure immediate circulation, evaluating the cardiac output by small one pulse check.

1. Character
2. Rate
3. Location
   a. Radial greater than 80 systolic
   b. Femoral greater than 70 systolic
   c. Carotid greater than 60 systolic
4. Capillary filling
   a. Abnormal—greater than 2 seconds

After assuring that the patient has a pulse, immediately check for massive hemorrhage. Use direct pressure to control such hemorrhage.

D. Demeanor—neurologic assessment of primary survey is divided into two components:

1. Pupils
   a. Equality
   b. Reactivity
   c. Size
2. Level of Consciousness
   a. A. Alert
   b. V. Response to vocal stimuli
   c. P. Response to painful stimuli
   d. U. Unresponsive

E. Expose—the patient must be adequately exposed in order to accomplish appropriate evaluation.

II. Resuscitation

A. Apply military antishock trousers (MAST) to mobilize 1,500 to 2,000 cc in the lower extremities and abdomen and to increase lower extremity peripheral resistance. This accomplishes three functions.

1. It increases cardiac output.

2. It provides most of the circulation through the ischemia-sensitive heart, brain, and lung portions of the circulation.

3. It also retards intraabdominal hemorrhage. The inflation of the military antishock trousers is based on the patient's blood pressure. Measurement of the pressure inside the trouser compartments is not an adequate method of gauging changes in the patient's blood pressure. The trousers remain inflated until the patient's blood pressure returns to 100 mm Hg or higher.

B. Insert two large-bore peripheral IV's. Insertion of central IV's is not appropriate at this point of the patient's care, as it takes too much time. Just as much fluid can be administered as rapidly through peripheral IV's. When the MAST trousers are inflated first, the peripheral veins are much easier to access.

III. Secondary Assessment

A. The patient is evaluated from the top of the head to the bottom of the toes, reevaluating each individual system to identify the possible causes of shock.

IV. Definitive Care

A. After appropriate stabilization procedures have been accomplished, including splinting, bandaging, applying compression dressings over major and minor hemorrhages, the patient should be transported as rapidly as possible to a treatment facility capable of managing the injuries present.

B. The patient's vital signs, including pulse, capillary filling, circulation, respiration, skin color, diaphoresis, level of consciousness, and pupillary changes should be monitored at least every 5 minutes throughout the assessment, stabilization, and transportation phases of patient care.

## Cardiogenic Shock

Cardiogenic shock occurs when cardiac output decreases because of abnormalities in the heart. It occurs in 10 to 15 percent of patients with myocardial infarction. It may also be caused by cardiac arrhythmias, chronic congestive heart failure, or pericardial tamponade (where blood in the pericardial sac prevents effective heart action).

The physiologic effects of cardiogenic shock are similar to those of hypovolemic shock. The reflex response to decline in cardiac output in cardiogenic shock is similar to that seen in hypovolemic shock: sympathetic outflow increases, raising total peripheral resistance through vasoconstriction in the skin, kidneys, and gastrointestinal tract. This increases blood pressure toward normal, but cardiac output remains low. Increased total peripheral resistance also increases the workload on the left ventricle and therefore increases its need for oxygen. In myocardial infarction, the heart is unable to increase its oxygen supply to meet the increased demand, and the area of infarction may increase. Changes in the capillary beds in cardiogenic shock resemble those seen in hypovolemic shock.

The signs and symptoms of cardiogenic shock are similar to those of hypovolemic shock. In cardiogenic shock, though, these signs and symptoms coexist with those of the underlying cardiac problem.

To treat cardiogenic shock, you should:

- Establish an airway.
- Administer oxygen. Assist ventilation, if necessary.
- Take vital signs.
- Monitor cardiac rhythm.
- Start an IV with D5W at a keep-open rate for drug administration.
- Keep the patient at normal temperature. Use blankets in case hypothermia develops.
- Monitor the state of consciousness, pulse, and blood pressure.
- Administer drugs to correct specific cardiac problems, if they are ordered by the physician.

## Septic Shock

Septic shock develops in some patients with sepsis, which is the presence of bacteria and bacterial toxins in the blood stream. Sepsis most frequently occurs in patients who have infections in other parts of their bodies. Common conditions that predispose to sepsis in patients with infections elsewhere are diabetes, cancer, cirrhosis, immunosuppressive drug therapy, biliary tract obstruction, prostatic hypertrophy with urinary tract infection, ulcerative colitis, and postpartum and postabortion infections.

There are several physiologic effects of septic shock. Sepsis is most frequently caused by gram-negative bacteria. These bacteria produce and release endotoxins, which contribute to the shock state. In septic shock, there is increased cardiac output, decreased total peripheral vascular resistance, hypotension, peripheral pooling of blood, and lactic acidosis. These effects can be partly explained by arteriovenous shunting, which occurs in specific shock. Arteriovenous shunting is circulation of blood from arteries to veins, bypassing the functional capillary beds.

In addition, the endotoxin produced by gram-negative bacteria combines with plasma proteins to produce a sympathomimetic (mimicking effects of the sympathetic nervous system) product. This, combined with reflex sympathetic stimulation in response to decreased blood pressure, produces vasoconstriction in precapillary arterioles and postcapillary venules in the skin, kidneys, and digestive organs. This leads to lactic acidosis, followed by arteriolar vasodilation and peripheral pooling of blood as seen in hypovolemic shock.

The signs and symptoms of septic shock resemble those of hypovolemic shock. However, in septic shock, the skin may remain warm and dry in spite of arteriolar vasoconstriction, because of the large cardiac output circulating through arteriovenous shunts. In addition, the patient in septic shock usually has an elevated body temperature due to the underlying infection.

To treat septic shock, you should:

- Establish an airway.
- Administer oxygen. Assist ventilation, if necessary.
- Take vital signs.
- Start at least one IV line with a large-bore (14–16 gauge) catheter. Infuse normal saline, Ringer's solution, or albuminate.
- Keep the patient at normal temperature. Sponge if febrile, using cool water or alcohol. (Colder solutions cause shivering.)
- Monitor cardiac rhythm.
- Monitor the state of consciousness, pulse, and blood pressure.
- If you are ordered by the physician to do so, administer methylprednisolone (Solu-Medrol) in the field. Drug therapy for septic shock includes antibiotics to control the organisms causing the infection. Antibiotics are usually administered after the patient reaches the hospital, rather than in the field.

## Neurogenic Shock

Neurogenic shock results from loss of normal vasoconstriction in both resistance vessels (arterioles) and capacitance vessels (large veins). Neurogenic shock occurs with spinal cord transection or severe spinal cord injuries, which interrupt fibers traveling from the brain stem's cardiovascular centers to the sympathetic centers in the thoracolumbar spinal cord.

Neurological and neurovascular diseases, such as demyelinating diseases and diabetes, may likewise cause loss of autonomic control. Adrenal medullary insufficiency also impairs sympathetic response to decreased blood pressure. Drugs that depress the central nervous system may also produce neurogenic shock. There are also transient and easily correctable forms of neurogenic shock such as fainting at the sight of blood and hypotension due to acute gastric distention (dilatation).

Neurogenic shock differs from the other types of shock in the loss of reflex sympathetic response to decreased blood pressure. Reflex peripheral vasoconstriction no longer occurs when blood pressure decreases. The loss of vasoconstriction increases the capacity of the large veins without increasing the blood volume. Because the blood volume is then smaller than the vascular space, venous return decreases. Since the heart receives less blood from the veins, it has less blood to pump to the arteries, and the cardiac output falls, further lowering blood pressure.

Reflex sympathetic stimulation of the heart is also lost in neurogenic shock. This means that the rate and force of cardiac contraction do not increase when blood pressure falls.

Because the sympathetic response to falling blood pressure is absent, the signs and symptoms of neurogenic shock differ significantly from those of other types of shock. The blood pressure will be low, but the pulse will be normal or low, rather than increased. Similarly, the skin is dry, warm, and may even be flushed, rather than being cold, clammy, and pale.

Neurogenic shock may be a transient phenomenon, if it is caused by fainting or gastric dilatation. In these cases, the patient should be kept flat, and the underlying problem—gastric dilatation or an upsetting environment—should be corrected.

Severe neurogenic shock may occur following spinal cord transection or severe spinal cord injury. In these cases, the paramedic should:

- Establish an airway.
- Administer oxygen. Assist ventilation, if necessary.
- Take vital signs.
- Apply and inflate the MAST. This returns two units of blood to the heart.
- Repeat pulse and blood pressure readings.
- Start at least one IV line with a large-bore (14-16 gauge) catheter. Rapidly infuse crystalloid or plasma derivatives, if the MAST has not restored the blood pressure.
- Keep the patient at normal temperature. Use blankets to prevent hypothermia. Because vasodilation in skin arterioles increases body heat loss, these patients have difficulty maintaining a normal body temperature.
- Maintain physiologic position with the legs elevated 30°.
- Monitor cardiac rhythm.
- Monitor the state of consciousness, pulse, and blood pressure.
- Administer vasoconstricting drugs to restore normal blood vessel tone, if they are ordered by the physician.

## Unit 5. Techniques of Management

### Peripheral Intravenous Insertion

Intravenous lines are initiated for two reasons:

- To provide a route for replacement of fluid, electrolytes, or blood products.
- To provide a lifeline for the administration of drugs. In states of low cardiac output (e.g., shock), blood is shunted away from the skin and skeletal muscles, and drugs administered subcutaneously or intramuscularly are absorbed at a slow and unpredictable rate. Intravenous administration insures that drugs reach the circulation.

Intravenous cannulas are basically of three types:

- Hollow needles (e.g., butterfly)
- Plastic catheters inserted over a hollow needle (e.g., angiocath)
- Plastic catheters inserted through a hollow needle

In the field, the over-the-needle catheter is generally preferred because it is more readily secured than the hollow-needle type and less cumbersome than the through-the-needle type. The through-the-needle type, in addition, may shear part of the catheter and cause it to embolize. The catheter used should be of large gauge (14 to 16 gauge for an adult), especially if massive quantities of fluid must be infused.

Use the following procedure in inserting a peripheral IV. Explain to the patient what will be done. Few people are entirely free from anxiety about needles and IV's. When people are ill, their anxieties may increase. Try to reduce this fear by explaining (1) why the IV line is necessary and (2) exactly what you will be doing. Remember that even though starting an IV may be a routine medical activity, it is not routine for the patient. An unhurried, informative, and confident attitude on your part can do much to ease the patient's fears.

When assembling the equipment, you should:

- Select the fluid ordered by the physician and inspect the container. In general, plastic bag infusion sets are preferable to bottles in the field, since bottles are liable to break. Whatever container is used, it should be checked for seal leakage, contamination, cloudiness, and the manufacturer's expiration date.
- Select the appropriate infusion set—a standard set for fluid replacement, a microdrip set for a keep-open line. After attaching the infusion set to the solution container, clamp the tubing and squeeze the reservoir on the infusion set until it is about half full. Next, open the clamp and clear the air from the tubing.
- Select the cannula.
- Also assemble

—Antiseptic cleaning solution, preferably an iodine swab.

—Sterile dressing (4- x 4-inch gauze).

—Adhesive tape cut into strips of appropriate length.

—20 ml syringe in which to collect a blood sample.

—Arm board.

—Pen and label for container identification.

—Vacutainer tubes for blood samples; two red-top and one purple-top.

—Tourniquet. This may be soft rubber tubing, a commercial tourniquet, or a blood pressure cuff. The latter permits the best control and often enables you to find a vein when other means fail. To use a blood pressure cuff as a tourniquet, determine the systolic pressure first, then inflate the cuff to about 20 mm Hg below the systolic pressure and clamp the tubing with a hemostat. When you are ready to release the tourniquet, the hemostat can be unclamped.

To select a suitable vein, you should apply a tourniquet at midarm, above the antecubital fossa, checking to make sure that a pulse is still present after the tourniquet is in place. Inspect the hand and forearm for a vein that appears fairly straight and lies on a flat surface (see Fig. 3.8). It should be well fixed, not rolling, and should feel springy when palpated. You should avoid:

- Areas of bone articulation (joints)—IV's in these areas necessitate immobilizing the joint, a process which is both cumbersome and uncomfortable for the patient.

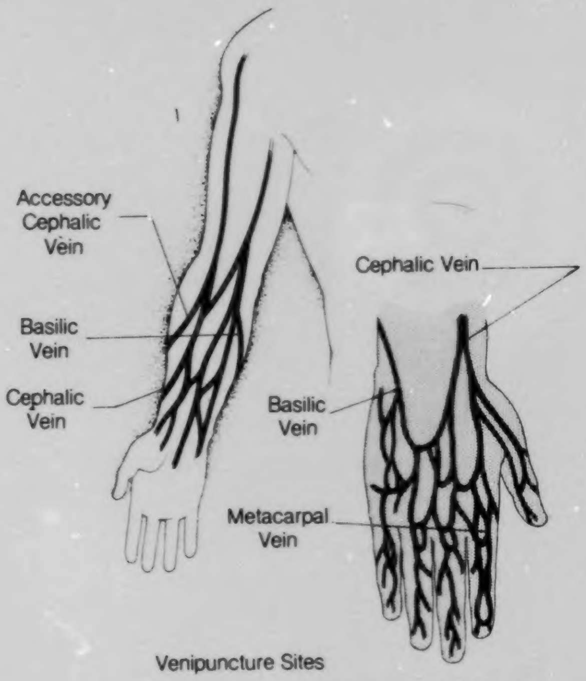


**Figure 8.** **A Vein in Hand/Forearm Suitable for Venipuncture**

- Areas where an arterial pulse is palpable close to the vein.
- Veins near injured areas.
- Veins of the lower extremities.

In general, the forearm is the preferred site, and the back of the hand is the second choice.

To prepare the venipuncture site, scrub the selected area with an iodine swab, starting from the area above the vein and wiping in widening circles around it, within a broad margin. Because some patients may react to iodine left on the skin, a final wipe with an alcohol swab is desirable.

To enter the vein, you should stabilize the vein by applying pressure on it below the point of entry. The skin should be punctured with the bevel of the needle pointing upward about 1 centimeter (cm) from the vein. You can enter the vein either from the side or from above. You should be able to feel the needle "pop" through into the vein. When the vein has been entered, blood will return through the needle. If you are using an over-the-needle catheter, advance it about 2 millimeters (mm) beyond the point where blood return was first encountered, sliding the catheter over the needle into the vein. The needle should be withdrawn and removed.

Next, draw the blood sample. Stabilize the catheter with one hand and attach the 20-ml syringe. Draw the blood sample and distribute it among the vacutainer tubes.

The next step is to release the tourniquet and connect the infusion tube to the catheter. The fluid should flow in a steady stream into the infusion reservoir. If the flow is slow, pull back very slightly on the catheter; its tip may be against the wall of the vein.

When a good flow is established, cover the puncture site with povodine-iodine ointment and a sterile dressing, tape the catheter securely in place, loop the IV tubing, and tape it to the adjacent skin. The taping should be generous and secure. The point of connection between the catheter and the infusion set should not be taped. On the tape, note the type of cannula used, the gauge, and the date (e.g., "14-gauge angiocath, 11/11/76").

The infusion should be adjusted to the flow rate ordered by the physician. To calculate the flow rate, you must know:

- The volume to be infused
- The time period over which it is to be infused
- The properties of the administration set; that is, how many drops (gtt) per milliliter it delivers

The rate is then calculated as follows:

$$\text{gtt/min} = \frac{\begin{matrix}\text{volume to be infused}\\ \text{X gtt/ml of administration set}\end{matrix}}{\text{total time of infusion in minutes}}$$

For example, if you are ordered to infuse 1 l (1,000 ml) of D5W in 2 hours and the administration set gives 10 drops per milliliter, the rate can be calculated as follows:

Total volume to be infused = 1,000 ml
gtt/ml = 10
time of infusion in minutes = 120

$$\frac{1000 \times 10}{120} = \text{approximately 80 gtt/min}$$

There are several potential complications of IV therapy; most of them can be avoided with proper attention to technique. These complications include:

- Infection, which is usually due to poor aseptic technique.
- Pyrogenic reactions, which result from foreign proteins or pyrogens that cause fever. Their presence in the infusion solution or administration setup may cause a reaction characterized by an abrupt temperature elevation (from 100° F to 106° F) with severe chills, backache, headache, malaise, nausea and vomiting, and, occasionally, vascular collapse. This reaction usually begins about half an hour after the infusion is begun. If such a reaction occurs, you should stop the infusion immediately and start another IV in the other arm with a new infusion solution; discontinue the old IV. If hypotension or shock is a prominent feature of the reaction, the patient should be treated for shock. Pyrogenic reactions can largely be avoided by carefully inspecting the bottle or bag before use for leakage or cloudiness.

- Local infiltration of IV solution into the subcutaneous tissues. This is quite common; it occurs when the needle or catheter is dislodged from the vein, especially when a small, thin-walled vein is used. Infiltration is characterized by

—Edema and pain at the site of the venipuncture

—A significant decrease in the infusion rate or complete cessation of flow

—Failure to obtain blood return into the catheter when the infusion bottle is lowered below the level of the needle and the clamp is opened wide.

If local infiltration occurs, the infusion should be discontinued immediately, and the needle or catheter removed from the vein. Cold compresses over the venipuncture site help reduce the swelling and diminish pain.

- Thrombophlebitis, or inflammation of the vein. Certain IV solutions are more irritating to veins than others, for example, dextrose solutions, which have a very low pH (D5W has a pH between 4.0 and 5.0) and hypertonic solutions, like 10-percent dextrose. Thrombophlebitis can also be produced by mechanical factors like excessive movement of the IV needle or catheter. It is manifested by

—Pain along the course of the vein, which will sometimes be inflamed and tender as well

—Redness and edema at the venipuncture site

—Rise of body temperature (occasionally)

When thrombophlebitis is suspected, the infusion should be stopped and the IV line should be discontinued. Warm, moist or dry compresses should be applied to the site.

- Circulatory overload. This may occur when excessive IV fluids are administered—through miscalculation of the rate, miscalculation of the patient's fluid needs, or a "runaway IV." The symptoms of circulatory overload are those of congestive heart failure: distention of the jugular vein, shortness of breath (dyspnea), and rales. These are discussed in more detail in Module VI.

- Air embolism. This may occur with any IV infusion, although it is most commonly seen during administration of blood under pressure. Air embolism can be prevented by taking appropriate precautions. You should:

—Inspect tubing for defects before using it.

—Make sure all connections are fitted tightly.

—Discontinue the infusion before the bottle is completely empty.

—Avoid circumstances that increase negative pressure in the tubing, such as elevation of the extremity receiving the infusion above the level of the heart and placement of the flow-regulating clamp too high on the tubing. The clamp should be at about the level of the patient's heart.

- Plastic embolus, which may result from catheter shear. Cannulas that involve plastic catheters advanced over or through a needle are subject to shearing; this is particularly true of the through-the-needle catheter. If such a catheter is withdrawn through the needle, it may catch on the sharp edge of the bevel and be sheared off, becoming a plastic embolus. For this reason, once a catheter is advanced over or through a needle, it should *never* be pulled back. If it is necessary to remove the catheter, *first* withdraw the needle, then withdraw the catheter.
- Inadvertent arterial puncture, which may occur if the vein selected for cannulation lies close to an artery. If the artery is punctured, blood under pressure will spurt intermittently out of the catheter. The bright red color of arterial blood and its unique flow characteristics should alert you to the error. Immediately withdraw the needle or catheter and apply firm pressure over the puncture site for at least 5 minutes, or until bleeding stops.

### * CENTRAL INTRAVENOUS INSERTION:

In some systems, cannulation of the external jugular, internal jugular, and/or subclavian veins is taught to paramedics. In addition to the possible complications mentioned for peripheral IV's, cannulation of these veins carries hazards of inadvertent air embolism from air sucked in during venipuncture and pneumothorax from accidental puncture of a lung. Therefore, these techniques should only be performed by persons thoroughly trained in their use.

Preparation for cannulation of these vessels is essentially the same as that for cannulation of a peripheral vein. However, as a general rule, the through-the-needle catheter is easier to use—especially for the internal jugular and subclavian vein.

The external jugular vein runs behind the angle of the jaw downward and obliquely backward until it pierces the deep fascia of the neck just above the middle of the clavicle; the external jugular vein ends in the subclavian vein, where there are valves to retard backflow (see Fig. 3.9).

The procedure for external jugular cannulation is as follows. You should:

- Place the patient in a supine, head-down position to fill the jugular vein; turn the patient's head to the side opposite the intended venipuncture site.
- Cleanse and anesthetize the skin.
- Align the cannula in the direction of the vein, which runs downward and obliquely backward from the angle of the jaw to the middle of the clavicle. Aim the point toward the shoulder on the venipuncture side.
- Make your puncture midway between the angle of the jaw and the middle of the clavicle; stabi-

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*Indicates optional skill.

lize the vein lightly by placing one finger on it just above the clavicle.

- From there, proceed as described for cannulation of a peripheral vein. Be careful not to let air enter the catheter once it is inserted. Quickly attach the infusion set as soon as blood return is established.
- Tape the line securely, but do not put circumferential dressings around the neck.

The internal jugular vein runs anteriorly, medially, and inferiorly within the neck. It emerges from the base of the skull between the angle of the jaw and the bone behind the ear (the mastoid process of the temporal bone). It then enters the carotid sheath behind the internal carotid artery, and runs posterior and lateral to the internal and common carotids. Finally, near its termination, the internal jugular vein is lateral to and slightly in front of the common carotid artery. It ends beneath the medial end of the clavicle where it joins the subclavian vein (see Fig. 3.10).

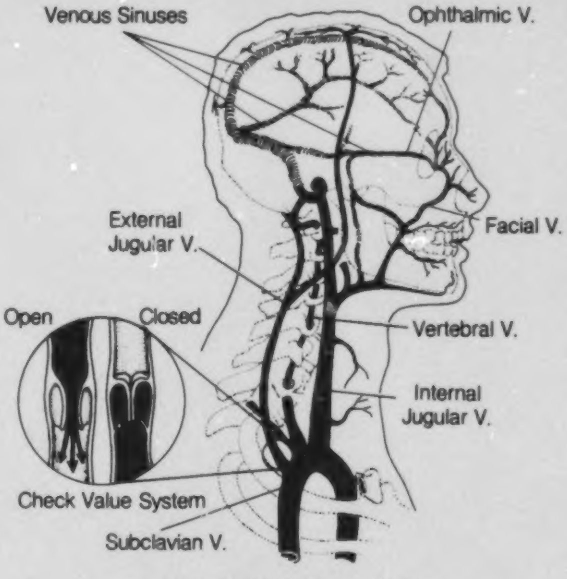
The procedure for internal jugular venipuncture from an anterior approach is as follows. You should:

- Place the index and middle fingers about 3 cm from the midsternal line, and retract the carotid artery medially, away from the anterior border of the sternomastoid muscle.
- Introduce the needle at the midpoint of this anterior border, halfway between the clavicle and the angle of the jaw.
- Direct the needle toward the nipple at a 30° to 45° angle with the frontal plane.
- Stop advancing the needle when blood comes back to the transparent back part of the needle.
- Slowly advance a cannula over the needle; remove the needle and attach the IV tubing; secure the cannula with adhesive tape.
- If blood which looks like arterial blood comes back with high pressure, remove the cannula and apply firm pressure for 5 minutes to avoid hematoma.

The procedure for internal jugular venipuncture from a posterior approach is as follows. You should:

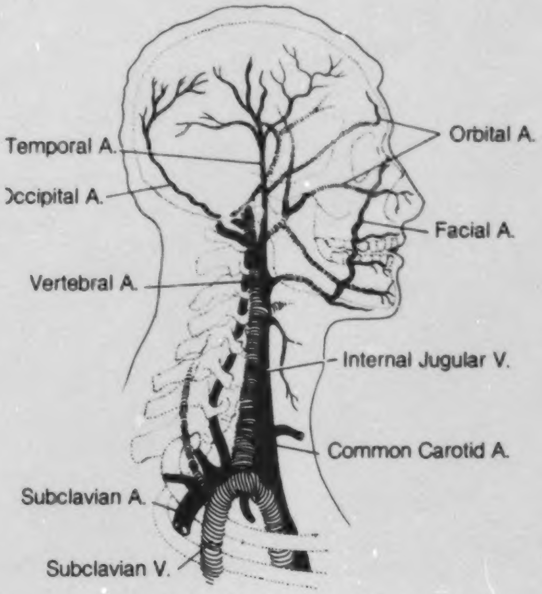
- Rotate the face and chin to the opposite side.
- Retract the sternomastoid muscle anteriorly and medially by placing the index and middle fingers at the lower third of the muscle.
- Introduce the angiocath or intracath needle about 2 inches above the clavicle at the lateral border of the sternomastoid.

The subclavian vein is a short vein which is approximately 3 to 4 cm in diameter in the adult. It travels medially behind the medial third of the clavicle. It begins as an extension of the axillary vein at the lateral border of the first rib, and then crosses over the first rib and passes in front of the anterior scalene muscle, which separates it from the subclavian artery running behind it. The vein continues behind the medial third of the clavicle, where it is immobilized by small attachments to the rib and clavicle. Then it unites with the internal jugular vein to form the innominate vein. The apical pleura of the lungs are in contact with the subclavian at its junction with the internal jugular vein (see Fig. 3.11).



Veins of the Neck and Head

**Figure 9. External Jugular and Subclavian Veins**



Arteries of the Neck and Head

**Figure 10. Internal Juglar and Subclavian Veins In Relationship to the Comon Carotid Artery**

The procedure for cannulation of the subclavian vein is as follows. You should:

- Insert the needle 1 cm below the junction of the medial and middle thirds of the clavicle.
- Hold the syringe and needle parallel to the patient's chest wall.
- Direct the needle toward the opposite shoulder. Establish a point of reference by pressing your fingertip firmly into the suprasternal notch and directing the course of the needle toward the opposite axilla.
- When the lumen of the subclavian vein has been entered, rotate the needle so that it is facing more toward the feet, since the catheter must make a turn into the innominate vein.
- Proceed as for a peripheral IV, being careful not to let air enter the cannula after it is inserted.

## Military Antishock Trousers

As was noted earlier, the cardiovascular system can be divided into three portions: the pump, the fluid, and the container. If there is to be adequate cardiac output, the pump must be kept primed. If the volume is low, the pump is not well-primed. If the container can be made smaller, the reduced volume may contain sufficient fluid to prime the pump for a limited period of time. Military antishock trousers (MAST) accomplish this. Like the G-suit originally developed to prevent blackouts in high-performance jet aircraft in World War II, the device applies pneumatic pressure to the lower extremities and abdomen, making the vascular container smaller in those areas. Studies have shown that over the period when the MAST is utilized to manage acute shock, there is only minimal interference with adequate circulation and perfusion in the enclosed parts of the body.

The devices presently available surround the lower extremities and abdomen. When they are inflated to their maximum, they reduce the container size enough to compensate for a blood loss as great as 30 percent. This is enough to restore adequate perfusion to the oxygen-sensitive tissues in the heart-brain-lung circulation, even in class 3 or class 4 shock, until adequate whole blood and crystalloid can be added to restore the cardiovascular fluid volume.

In addition, the external pressure can indirectly apply enough extra vascular pressure to decrease blood loss from either external or internal hemorrhage. Arterial pressure does not have to be exceeded to accomplish this. The pressure needs only to exceed the difference between the intravascular pressure and the pressure in the surrounding tissue. This makes the device extremely useful in controlling intraabdominal blood loss or the blood loss associated with fractures in which the bone is broken into several pieces (comminuted fractures).

The trousers are also used to immobilize fractures of the femur and pelvis, just as a pneumatic splint can be applied to extend above and below the fracture. The retroperitoneal blood loss associated with a severely fractured pelvis can also be controlled by the use of MAST.

Although patients can breathe adequately with the increased abdominal pressure applied by the trousers, the elevation of the diaphragm associated with the use of the device probably reduces the total ventilatory capacity of the lungs. For this reason, as in all cases of shock, oxygen should be administered. If there are other conditions present which further compromise pulmonary ventilation, such as air in the chest cavity (pneumothorax), additional attention must be given to assure that the patient's color remains good. In intracranial injuries, the increased intracranial pressure will decrease the vascular volume within the brain, making maintenance of adequate perfusion pressure to the brain important. The use of military antishock trousers when head injuries are associated with hemorrhagic and other types of shock helps maintain cerebral perfusion pressure.

In cardiac arrest, adequate CPR provides only about 30 percent of the usual cardiac output. If most of this cardiac output can be distributed into the heart-brain-lung circulation, these critical tissues would be provided with better perfusion. Studies have demonstrated that the use of military antishock trousers on the lower extremities and abdomen increases both the preload and lower half of the body's peripheral resistance enough to improve carotid blood flow while CPR is being given.

Because up to 2,000 cc of blood may be immobilized from the lower extremities and presented as preload to the heart, pulmonary edema can be worsened by the use of MAST. Pulmonary edema represents the only contraindication to their use.

Because inflation of the pneumatic antishock trousers provides a translocation of blood into the upper half of the body up to 2,000 cc, a rapid deflation will provide the circulation of an equal or greater volume. The MAST should very seldom, if ever, be deflated before adequate blood volume has been restored. Rapid deflation of the device will cause the patient to return to shock. Although the total pathophysiology is not well understood, it is more difficult to resuscitate the patient from the second "shocky" episode than from the first.

Any patient who is considered a possible candidate for the use of military antishock trousers should be placed on the device as he or she is moved onto the roller or onto the long backboard. Although the device can be put on a supine patient already on a roller or on the ground, it is more difficult and time-consuming to do so. Preplanning in any emergency situation always achieves the best results.

### INDICATIONS FOR USE OF MAST

1. Shock (all causes, unless associated with pulmonary edema).
2. Blood pressure less than 80 mm Hg systolic in any adult patient and less than 100 mm Hg systolic if accompanying signs and symptoms indicate shock.
3. Intraabdominal hemorrhage such as that associated with a fractured liver or spleen with automotive trauma or dissecting aortic aneurysm (distention of the aorta caused by blood traveling between the layers of the blood vessel wall).
4. Hemorrhage of an extremity such as that associated with a comminuted fracture of the femur or pelvis.
5. Stabilization of fractured femur or pelvis.
6. Cardiac arrest when CPR is indicated.

### CONTRAINDICATIONS

1. Pulmonary edema.

### APPLICATION

After MAST are appropriately positioned on the patient, the leg and abdominal compartments are inflated simultaneously while the patient's blood pressure is closely monitored. Because the amount of fluid necessary to manage the shock varies from patient to patient, the amount of external pressure necessary to translocate this fluid also varies from patient to patient. For this reason, monitoring the pressure inside the various compartments is not beneficial. It is the patient who is in shock, so it is the patient's pressure that must be monitored.

While the trousers are being inflated, the patient's blood pressure is constantly monitored. When the blood pressure returns to within normal limits (or above 100 mm Hg systolic), inflation is stopped. When the patient has been adequately stabilized for transport, the blood pressure must be constantly reevaluated. Because the velcro fastenings can slip, the trousers may develop a leak. For a variety of other reasons, such as atmospheric pressure change in air transfer or temperature change in moving a patient from a hot environment to a cooler environment or vice versa, attention must be paid to maintaining proper blood pressure by reinflating or further inflating the trousers as necessary.

### REMOVAL

The trousers are removed only after gradual deflation preceded by adequate fluid volume replacement. If intraabdominal blood loss is suspected, this deflation should be done in the operating room. You should be very familiar with the complications arising from inappropriate deflation. You should also be sure that other medical personnel who assume responsibility for the patient understand these complications. When deflation is necessary, it should be started with the abdominal segment and continued with each leg individually. Allow a small amount of air to escape from the inflation valve, and check the patient's blood pressure. Continue alternating gradual deflation and monitoring the patient's blood pressure. If the patient's blood pressure drops as much as 5 mm Hg, stop the deflation until fluid replacement has brought the patient's pressure back within previous limits.

## Unit 6. Assessment of the Trauma Patient

The management of a patient with several kinds of injuries requires close adherence to a set of priorities. If you deviate from this stepwise approach to the patient, you may overlook an injury or a problem of major significance. This review of the steps of the initial assessment should serve to bring together those aspects of anatomy, physiology, and pharmacology that have been presented in this module and the previous modules. Only with a thorough understanding of this information and the information contained in the respiratory cardiac, soft tissue, and skeletal trauma modules will you be able to understand signs and symptoms, convert this information into a working diagnosis, and formulate a rational approach to the management of the patient.

### SURVEY OF THE SCENE

As the emergency unit approaches the scene and the vehicle and patients involved come into view, you should survey the entire emergency scene, noting the placement of the vehicles and the probable path traveled just prior to, during, and following the crash. From this information, you should be able to deduce what injuries might be expected and to anticipate

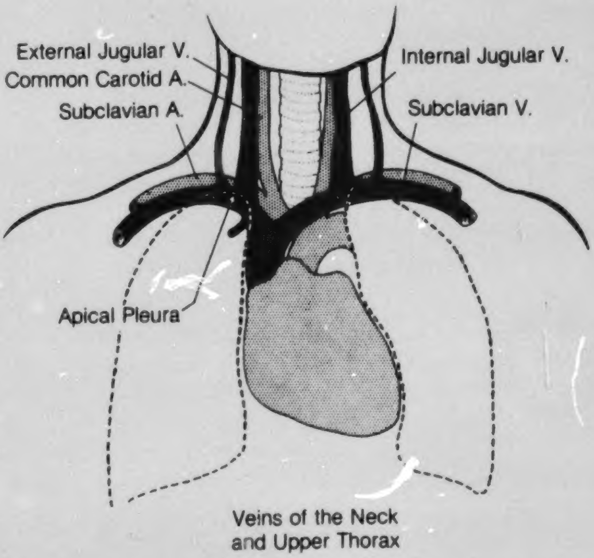


**Figure 11. Apical Pleura, Subclavian and Internal Juglar Veins**

where patients not readily visible may be lying. In addition, you should be aware of the bystanders, other emergency vehicles, the flow of traffic, the possibility of fire, the wind direction, and any environmental problems which might influence the patient's care. Also note whether law enforcement officers, fire personnel or knowledgeable bystanders are available to render assistance. Quickly estimate the equipment needed for patient care, for extraction, and as backup EMS equipment. Unless you train yourself to observe the scene and answer all of these questions in a scene survey, proper patient care may be delayed. The next step is rapid identification of all patients, and triage to ascertain which requires first priority in patient care.

As you enter the vehicle, you should be acutely aware of the possibility of fire. The first step is to turn off the ignition. If there is a bystander who can rapidly be shown the use of a dry-power fire extinguisher, do so. The user of the fire extinguisher should be admonished to direct it at the EMT and at the patient and not to try to put out the fire. Inexperienced individuals cannot put out a gasoline fire with a small dry-powered extinguisher. It should be used only to prevent fire near the patient and the EMT and to cool them while they escape from the vehicle if necessary.

## INITIAL ASSESSMENT

Parts A, B, C, D, and E remind you of the priorities in the primary survey.

### I. Primary Survey

A. Airway. The airway is initially managed by forward projection of the jaw (mandible), using the chin lift, jaw lift, or jaw thrust procedures. The airway should be maintained patent with the nasal airway, oral airway, esophageal obturator airway, or the nasal endotracheal. When establishing the patent airway, be sure that the cervical spine is not manipulated and that the neutral position of the neck is maintained. Also make sure that facial, oral, or pharyngeal injuries are not producing significant hemorrhage which could be aspirated. If such a condition exists, tracheal isolation from the bleeding area must be accomplished with an endotracheal tube. Nasal intubation is recommended. However, if this cannot be accomplished and oral intubation is the only possibility, proper in-line traction during the insertion of the endotracheal tube is mandatory.

If the larynx is totally obstructed, the Jet Insufflation technique will work for 30 to 45 minutes, until a more effective mechanism can be established. Such a technique should be necessary only in a severe laryngeal fracture, laryngeal obstruction by a foreign body or vocal cord edema from an allergic reaction.

B. Breathing. The three major problems that most often compromise breathing should be suspected. They are tension pneumothorax, open pneumothorax, and flail chest. A quick visual inspection of the chest should identify a flail chest or a sucking chest wound. It must be emphasized that sucking chest wounds can be present in the armpit (axilla) as well as the posterior part of the thorax. Never assume that because the anterior thorax is clear, the posterior thorax is free of injuries. The most frequently missed sucking chest wound is in the axilla. If the arm is raised when the injury occurs, it may fall back down to the patient's side, so that the injury is not visible. Particular attention should be paid to this area.

If any of these three injuries is significantly compromising ventilation, it should immediately be stabilized. Stabilization may consist of nothing more than placing the hand over the sucking wound to stop the flow of air or on the flail segment to stop the paradoxical movement. More definitive treatment can be carried out later.

C. Circulation. A quick check of the pulse will give you a good idea on the cardiac output; when it is combined with a check of the capillary refilling time, you will have a good estimate of peripheral perfusion.

If the pulse is slow and strong with good capillary refilling, you may assume that the peripheral perfusion is adequate for the needs of the patient during the primary assessment. If not, you should consider the possibility of shock, hypoperfusion and metabolic acidosis.

A slow pulse with warm, dry, pink skin and good capillary filling is not an absolute assurance that an injury is not present. Spinal cord shock produces this pattern.

Hemorrhage Control. External hemorrhage is controlled by direct pressure over the bleeding site using the hand, 4 x 4's, abdominal dressings, or some mechanism to obtain strong pressure. Once pressure is applied to a bleeding point or a large bleeding wound, it must be maintained for a minimum of 5 minutes.

The use of hemostats is time-consuming, and tourniquets, if improperly applied, increase blood loss rather than decrease it. Neither has any place in the field care of patients.

D. Disability. Neurologic Exam. Simply by talking to the patient and moving his extremities, you can usually assess what level of the consciousness in the AVPU system he is. Although evaluation of pupillary size and reactivity may be difficult in the field, it should be attempted in order to establish a base line.

E. Expose. The patient's entire body should be exposed for a thorough evaluation. Protection from the environment during this evaluation is of major importance.

### II. Resuscitation

It is assumed that airway breathing, cardiac arrest, and hemorrhage are handled immediately upon their identification in the primary survey. Shock, however, is not managed in the primary survey. Its management is deferred until the primary survey is completed. The application of military antishock trousers is the first step in its initial management. Not only can this device mobilize up to 30 percent of the patient's blood volume to the upper half of the body; it also controls external hemorrhage, hemorrhage of pelvic fractures, and hemorrhage from an intraabdominal source. The pressure of the shock trousers does not need to exceed arterial pressure to accomplish any of these goals. It must only exceed the difference between intraluminal pressure and extravascular pressure to stop leakage from the vessel. Changes in blood pressure depend on the amount of blood lost. A lower external pressure will translate a lesser amount of blood than will higher external pressure. It is for this reason that the inflation of the pneumatic antishock device is based on the patient's pressure and not the external pressure of the device.

It is just as important to reduce blood flow from the vessels within the abdominal cavity as it is to reduce blood flow from external vessels. Blood is lost to the circulatory cardiovascular system no matter where it goes. There is a tendency to forget that blood loss into an internal cavity is just as lost from the cardiovascular circulation as blood lost onto the ground.

Intravenous therapy to the patient in severe shock must be administered as rapidly as possible. Two large-bore IV's are started, and Ringer's lactate is run as fast as possible until the patient's blood pressure stabilizes.

### III. Secondary Survey

Secondary assessment begins at the top of the patient's head and proceeds toward the feet until the entire body is examined. The utilization of the look-listen-feel technique identifies the pathology present. Examine the head, beginning with the skin, looking carefully at the eyes, nose, and mouth to identify contusions, abrasions, or lacerations. It is difficult to examine the scalp, particularly the back of the head. Since moving the head would perhaps increase cervical, spinal or cord damage, use gentle palpation to identify lacerations and possible depressed skull fractures or penetrating injuries. Palpation over the bones of the face, maneuvering the mandible and maxilla, will identify any injuries present. It is important to pay careful attention. Such good physical examination will lead you through a complete examination of the entire body. Utilizing the technique described for the head, looking carefully at the skin, palpating bones, and soft tissues and checking for any abnormalities, continue the physical examination to the bottom of the feet.

After the examination is completed, priorities as to the management of the injuries identified may change. Whether the injuries are managed at the accident site, inside the car, or with careful hand mobilization after the patient has been placed on the stretcher in the ambulance is determined by the environment, weather conditions, number and attitudes of bystanders, possibility of fire, precariousness of the position of the car, difficulty of extraction, and many other factors.

The major problem that many individuals run into, both in the field and in the emergency department, is spending excessive time carrying out diagnostic evaluations or maneuvers which are not beneficial to the patient. It is obvious that a prolonged diagnostic exam utilizing the otoscope to visualize all portions of the external canal and the tympanic membrane is not going to affect the outcome of the patient or change the management in the field. The presence of blood behind the T–M, identifying a basilar skull fracture or a laceration of the external canal, is not going to change prehospital patient care. The patient may still be stabilized on the backboard, an IV started, and the patient transported to the hospital. Not only do excessive prehospital maneuvers tend to frustrate and aggravate the physicians awaiting the patient's arrival in the emergency department; it may also delay definitive patient care which cannot be given in the field.

The kind of complete examination described above should require only 3 to 4 minutes. Following such evaluation and prehospital stabilization and resuscitation, the patient can be transported to the hospital emergency department at normal speed, obeying all traffic laws. Transportation with flashing red lights and sirens increases the possibility of accidents by 40 percent. A good service operating at the EMT-Paramedic level will transport less than 5 percent of the patients to the hospital using lights and sirens.

### IV. Definitive Care

Definitive care is the stabilization and preparation of the patient for transportation to the medical care facility.

## Glossary

**acid:** Any compound of an electronegative element with one or more electropositive hydrogen ions; may cause severe burns.

**agglutination:** The clumping together of blood cells when incompatible bloods are mixed; adhesion of surfaces of a wound.

**air embolism:** The presence of air bubbles in the heart or blood vessels causing an obstruction; caused by surgery or trauma.

**alkali:** Any compound of an electropositive element in combination with an electronegative hydroxyl ion or similar ion; alkaline compounds are caustic and can cause severe destruction of tissue.

**anion:** An ion carrying one or more negative charges.

**antecubital:** In front of the elbow; at the bend of the elbow.

**aseptic:** Free from germs, from infection, and from any form of life.

**autotransfusion:** A transfusion effected by redirecting the patient's own blood from one part of the body to another.

**base:** A compound that dissociates with formation of a hydroxyl ion; a solution having a pH greater than 7.0.

**bivalent:** Having two charges, such as $Ca^{++}$ (calcium ion).

**buffer:** A substance in a fluid that tends to minimize changes in pH that would otherwise result from adding an acid or base to the fluid.

**cardiogenic:** Of cardiac origin.

**cation:** A positively charged ion, such as $Na^+$ (sodium).

**colloid:** An intravenous solution containing protein.

**crystalloid:** A substance capable of crystallization that, in solution, can be diffused through animal membranes.

**dehydration:** The condition that results from excessive loss of body water.

**edema:** A condition in which fluid escapes into body tissues from vascular or lymphatic spaces and causes local or generalized swelling.

**electrolyte:** A substance whose molecules dissociate into charged components (ions) when placed in water.

**erythrocyte:** A red blood cell.

**extracellular fluid:** That portion of the total body water outside the cells; composed of the interstitial fluid and plasma.

**hemoglobin:** The oxygen-carrying pigment of the red blood cells; when it has absorbed oxygen in the lungs, it is bright red and is called oxyhemoglobin; after it has given up its oxygen to the tissues, it is purple in color and is called reduced hemoglobin.

**hypertonic:** A solution having an osmotic pressure greater than a solution to which it is being compared (usually the intracellular fluid).

**hypotonic:** A solution having an osmotic pressure less than a solution to which it is being compared (usually the intracellular fluid).

**hypovolemia:** A decreased amount of blood in the body.

**ion:** An atom or group of atoms carrying a positive or negative electrical charge; ions may exist in solid, liquid, or gaseous environments, although those in liquid (electrolytes) are the most common and familiar.

**incompatibility:** In blood typing, the situation in which donor and recipient blood cannot be mixed without clumping or other adverse reactions.

**infiltration:** The deposit of fluid into tissues, often occurring as a result of administering fluid through an IV cannula that has penetrated the opposite wall of the vein.

**interstitial fluid:** The fluid bathing the cells; part of the extracellular fluid.

**intracellular fluid:** The portion of the total body water contained in the cells; usually about 45 percent of the body weight.

**intravascular fluid:** The portion of the total body water contained within the blood vessels; plasma.

**isotonic:** Having the same osmotic pressure as a reference solution, usually the intracellular fluid.

**jugular:** Pertaining to the neck.

**leukocyte:** A white blood cell.

**milliequivalent:** A unit of measurement for electrolytes based on a chemical combining power; defined as the weight of a substance present in 1 milliliter of normal solution.

**monovalent:** Having a single charge (such as the sodium ion $Na^+$).

**neurogenic:** Of or originating in the nervous system.

**osmosis:** The passage of pure solvent from a solution of lower solute concentration to one of higher concentration across a semipermeable membrane.

**overhydration:** A condition that results from excessive retention of fluids.

**pH:** A symbol used to indicate the acidity or alkalinity of a substance; on a scale of 14, 0 indicates high acidity, 14 indicates high alkalinity, and 7 indicates a neutral status.

**Rh factor:** An antigen present in the red blood cells of some individuals; when present, the individual is said to be Rh positive; when absent, the individual is Rh negative.

**saline:** Containing salt.

**shock:** A state of inadequate tissue perfusion that may be a result of pump failure (cardiogenic shock), volume loss (hypovolemic shock), vasodilation (neurogenic shock), or any combination of these.

**subclavian vein:** The large vein located beneath the clavicle and joining the internal jugular vein.

**thrombocyte:** Blood platelet; a cellular element of the blood involved in clotting.

**thrombophlebitis:** A condition in which inflammation of a vein leads to the formation of a clot (thrombus) in the vein.

**total body water:** The total fluid content of the body; equivalent to about 60 percent of body weight in the adult male.

**transfusion reaction:** Any adverse reaction (allergic, febrile, or hemolytic) produced in a patient due to a blood transfusion.

**vasopressor:** Any agent that raises the blood pressure by causing vasoconstriction.

**volume expander:** The intravenous fluid that stays in the vascular space; usually a colloid.

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## Module IV.
# General Pharmacology

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## Module IV.

# General Pharmacology

One important difference between the Emergency Medical Technician-Paramedic (EMT-P) and the Emergency Medical Technician-Ambulance (EMT-A) is that the paramedic is trained to administer drugs in the field. This difference allows the early treatment of life-threatening conditions. Lives can be endangered or lost, however, if a drug is given in the wrong dose or administered improperly. Therefore, it is essential for you, the paramedic, to be familiar with the pharmacologic agents that are used in the field—with their indications and contraindications, their side effects and dangers, and their appropriate forms and rates of administration. Acquisition of this information is not easy, and requires at first both memorization and practice. But with experience, you will become familiar with a large number of drugs used in emergency situations and will be able to calculate appropriate dosages quickly.

## Unit 1. Drug Information

A drug is a chemical compound administered as an aid in either the diagnosis, treatment, or prevention of a disease or other abnormal physiological condition. Drugs can be given in an attempt to alter the course of the disease (e.g., giving xylocaine to suppress a cardiac arrhythmia) or to relieve the symptoms of the pathophysiologic process (e.g., giving morphine to relieve the pain of a fractured arm).

Drugs come from four major sources: (1) animals, (2) plants, (3) minerals, and (4) chemical synthesis. For example, insulin—taken by diabetics to control elevated blood sugar—is prepared from the pancreas of cows and pigs. Until the early 1900's, most drugs came from medicinal plants. Today, drugs are still derived from different plant parts, including dried bark, roots, leaves, flowers, and seeds. Digitalis, a drug used in the treatment of heart failure, was isolated from the leaves of a wildflower called the purple foxglove (*Digitalis purpurea*). The opiate narcotics are derived from the poppy plant. Minerals like calcium, iron, and magnesium are important for normal growth and development and are administered as drugs in a variety of clinical situations. Calcium, for example, not only is an important component of bones and teeth but also increases the force of cardiac (heart) contraction. Most drugs used today are manufactured chemically (synthetically). Pharmacologists and chemists can design drugs to give specific therapeutic effects, while keeping side effects at a minimum. Some of the newer cardiac drugs and synthetic steroids were developed in this way.

### Drug Names

One of the factors that complicates pharmacology is that most drugs have at least four names. These names fall into four broad categories:

- Official name—This is the name under which the drug is listed in the *United States Pharmacopeia*. The *Pharmacopeia* is an official listing of drugs and their preparation, published every 5 years by a national committee of pharmacists, physicians, and other scientific personnel. A drug with the letters USP after its name is manufactured to meet standards set in the *Pharmacopeia*.
- Chemical name—This is an exact description of the drug's chemical structure and composition. It is of interest primarily to chemists and others involved in the manufacture of drugs.
- Generic name—The generic name is usually given to the drug by the company that first manufactures it, before an official name has been assigned. This name is generally shorter and simpler than the chemical name, although it is often derived from the chemical name.
- Trade name (trademark, proprietary name, brand name)—A trade name has the symbol ® in the upper right-hand corner, indicating that the name is registered by a particular manufacturer. The first letter of a trade name is capitalized. Since a given drug may be marketed by a number of manufacturers, it may have several different trade names.

Tetracycline, a widely used antibiotic, has the following names:

- Official name: tetracycline USP
- Chemical name: 4-dimethylamino -1, 4, 4a, 5, 5a, 6, 11, 12a octahydro -3, 6, 10, 12, 12a pentahydroxy -6-methyl-1, 11-dioxo-2-naphatacene carboxamide
- Generic name: tetracycline
- Trade names: Achromycin, Panmycin, Polycycline, Tetracyn

In this manual, drugs are called by their generic names. When a drug is widely known by its trade name, however, it will appear in parentheses (e.g., diazepam (Valium), norepinephrine (Levophed), furosemide (Lasix), naloxone (Narcan)).

## Drug Standards and Legislation

National standards and Government regulations insure that drugs sold by various manufacturers are accurately identified and are of uniform strength and purity. The following laws have been enacted by Congress in the last 70 years to protect consumers and patients:

- *The Pure Food Act of 1906.* This law was an attempt to protect the public from mislabeled, poisonous, or otherwise harmful foods and drugs. Requiring little more than the labeling of drugs, it was replaced in 1938 by the Federal Food, Drug, and Cosmetic Act.
- *The Federal Food, Drug, and Cosmetic Act (amended in 1952 and 1962).* This act required that labels list the possible habit-forming effects of drugs and give warning about possible side effects; authorized the Food and Drug Administration (FDA) to determine the safety and efficacy of drugs before they are marketed; and required that dangerous drugs be issued only on the prescription of a physician, dentist, or veterinarian.
- *The Harrison Narcotic Act (1914).* This act regulates the import, manufacture, sale, and prescription of opium, cocaine, and their derivatives. It requires precise recordkeeping in the dispensing of controlled drugs and the registration of manufacturers, pharmacists, and physicians with the Federal Government. The act specifies fines and imprisonment for the illegal possession or distribution of controlled drugs.
- *The Narcotic Control Act (1956).* This act increased the penalties for violation of the Harrison Act and also made the possession of heroin and marijuana illegal.

The following Federal agencies are involved in the regulation of drugs:

- The Bureau of Narcotics and Dangerous Drugs registers physicians and allows them to prescribe controlled substances.
- The Food and Drug Administration enforces the Federal Food, Drug, and Cosmetic Act.
- The Public Health Service regulates such biological products as vaccines and antitoxins.
- The Federal Trade Commission regulates drug advertising.

## DRUG FORMS

Drugs are available in many forms—both solid and liquid—each having special properties.

### SOLID DRUGS

Various solid forms include extracts, powders, pills, capsules, tablets, pulvules, suppositories, and ointments. Some are more appropriate for use in certain disorders than others.

### EXTRACTS

Extracts are concentrated preparations of a drug prepared by putting the drug into an alcohol or water solution and evaporating off the excess solvent to a prescribed standard. For example, liver extract, used in the treatment of certain anemias, is prepared by dissolving ground beef or pork liver and allowing the solvent to evaporate. The extract can then be incorporated into a tablet or capsule.

### POWDERS

Powders are drugs that have been ground into fine particles. Mixtures of powdered sodium bicarbonate and calcium carbonate are used as an antacid in the treatment of ulcers.

### PILLS

Pills are drugs shaped into balls or ovals to be swallowed and are often coated to disguise an unpleasant taste. Ferrous sulfate (iron), in the form of coated pills, is often prescribed to patients with anemia.

### CAPSULES

Capsules are gelatin containers enclosing a dose of medication that is usually in powdered form. Antibiotics are available in capsule form.

### TABLETS

Tablets are powdered drugs that have been molded or compressed into small disks. Aspirin comes in tablets.

### PULVULES

Pulvules resemble capsules, but are coated and cannot be separated. Pulvules are usually over-the-counter drugs (proprietary).

### SUPPOSITORIES

Suppositories are drugs that are mixed in a firm base that melts at body temperature. Shaped to fit various body orifices, suppositories may be used for their local action (glycerin suppositories, used to promote evacuation of the rectum) or systemic effect (aminophylline suppositories, used for bronchodilation).

### OINTMENTS

Ointments are semisolid preparations, usually containing medicinal substances, which are applied externally. Neomycin ointment, for example, is used as a topical antibiotic.

### LIQUID DRUGS

Drugs found in liquid form include the following: solutions, suspensions, fluid extracts, tinctures, spirits, syrups, elixirs, emulsions, and lotions.

### SOLUTIONS

Solutions are liquids containing one or more chemical substances that are entirely dissolved, usually in water. For example, normal saline solution, which is commonly used as an intravenous fluid, is salt dissolved in water at a concentration of 0.9 percent.

### SUSPENSIONS

Suspensions are preparations of a finely divided drug incorporated in a suitable liquid. All bottles containing suspensions must be shaken thoroughly before use, since when standing the ingredients tend to separate.

### FLUIDS EXTRACTS

Fluid extracts are concentrated forms of a drug prepared by dissolving the crude drug in the fluid in which it is most soluble. Fluid extracts are standardized, so that 1 milliliter (ml) contains 1 gram (g) of the drug.

### TINCTURES

Tinctures are alcohol solutions that usually contain a 10 percent drug extract. One example is tincture of iodine, used as a skin antiseptic.

### SPIRITS

Spirits are preparations of volatile substances dissolved in alcohol. Spirit of ammonia is used to rouse people from faintness with its pungent odor.

### SYRUPS

Syrups are drugs suspended in sugar and water to improve their taste. Cough syrup is a common example.

### ELIXIRS

Elixirs are syrups with alcohol and flavoring added.

### EMULSIONS

Emulsions are preparations of one liquid (usually an oil) distributed in small globules in another liquid (usually water). Emulsions are often used as lubricants.

### LOTIONS

Lotions are aqueous preparations containing suspended matter and other ingredients. Lotions must be shaken well before use. Calamine is a commonly used lotion.

One very useful book is the *Physicians' Desk Reference (PDR)* published by Medical Economics. This book is sponsored by drug manufacturers and contains information about commonly prescribed drugs. It discusses indications, contraindications, side effects, forms, and dosages of given drugs. In addition, the Drug Identification Index of the *PDR* contains pictures of the most common drugs—listed alphabetically by manufacturer. The PDR can prove helpful in both the field and emergency room when you are called upon to identify unknown drugs.

## Summary

Drugs are important agents in treating many emergency conditions, but they can have serious side effects if administered improperly. Drugs are derived from animal, plant, or mineral sources and can also be synthesized chemically. The purity, quality, and prescription of drugs are regulated by State and Federal agencies. Drugs come in a large variety of preparations that differ in their therapeutic properties and actions.

# Unit 2. Drug Actions

As a paramedic, you are responsible for knowing the action of each drug you administer. You must know not only when a specific drug should be administered but also what side effects to watch for after its administration.

Drugs can have both local and general (systemic) effects. Local effects result from the direct application of a drug to a tissue—thus, only a limited part of the body is affected. The area of redness surrounding an injection site and the skin discoloration following application of certain creams or ointments are examples of local effects. Antacids and laxatives, which act within the gastrointestinal tract but are not absorbed, are considered to have local rather than systemic effects.

To have systemic effects, a drug must be absorbed into the bloodstream and distributed throughout the body. Different drugs reach different concentrations in different tissues. For example, many drugs reach very high concentrations in fat, while others reach high concentrations in the kidneys.

## Factors That Influence Action of Drugs

There are many factors that influence the action of a drug on a patient. These factors include the patient's age and condition, the dosage of the drug, the elements that influence the absorption of the drug, the detoxification of the drug, and the elimination of the drug from the body.

### AGE OF THE PATIENT

The patient's age is an important factor. Some drugs, such as sedatives and narcotics, can affect the elderly more than younger patients.

### CONDITION OF THE PATIENT

The condition of the patient will have important effects on the action of the drug in that patient. A patient with heart disease or high blood pressure, for example, may be adversely affected by a dose of epinephrine. In another patient, without these conditions, the drug may prove therapeutic.

### DOSAGE

You should be familiar with several dosage levels. These levels are not constant among patients and can vary depending on the age, weight, and condition of the patient.

- Minimal—The smallest dose of a drug that will produce a detectable therapeutic effect.
- Maximal—The largest dose that can be given without producing a toxic effect.
- Toxic—A dose large enough to produce serious side effects.
- Lethal—A dose that is fatal.

### ABSORPTION

The absorption process is the passing of a drug into the bloodstream. The rate of absorption is determined by the method used to administer the drug.

### INTRAVENOUS

When a drug is administered directly into the bloodstream—that is, into a vein—absorption is immediate. The intravenous (IV) route is therefore preferred in many life-threatening situations, because delivery of the drug is guaranteed. Often it is advisable to start an IV line just to have a delivery route available if it becomes necessary to administer drugs rapidly. One danger of using the IV route, however, is that once a drug is given, its absorption cannot be stopped

### INTRAMUSCULAR

Intramuscular (IM) injections of drugs do not work as quickly as IV injections because the drugs are gradually absorbed, taking from a period of minutes to a period of hours. Absorption of medication given by this or the subcutaneous (SC or SQ) route depends on an adequate flow of blood to the muscles and peripheral tissues. Therefore, IM injections are given only to those patients with adequate peripheral perfusion, and never to those suffering from shock or cardiac arrest.

The IM injection usually involves volumes of about 1 to 5 ml and is given into the deltoid muscle or upper outer quadrant of the gluteus maximus muscle. (The technique for this and other types of injections is described in Unit 5 of this module.) The use of the deltoid muscle has the advantage of allowing the rate of drug absorption to be slowed if an untoward reaction occurs. If the patient develops shortness of breath, dizziness, itching, swelling, wheezing, or other signs of an allergic reaction following an IM or SC injection in the arm, a tourniquet should immediately be fastened about the injection site, and the patient treated for anaphylaxis. (See Module 10.)

### SUBCUTANEOUS

SC injections are given into the fat or connective tissue beneath the skin. Medications administered by this route are also absorbed more slowly and over a longer period than those given IV. The SC injection is sometimes used for administration of epinephrine in asthmatic attacks of moderate severity. It is usually given under the skin of the upper arm, the anterior thigh, or the abdomen.

### INHALATION

This method is used primarily for the administration of aerosol bronchodilators. Medihalers prescribed to some asthmatics are designed for giving medication by an inhalation route. In the field, you will not often be called upon to employ this treatment. The long-distance transport of an asthmatic, who may require aerosol medication, is the rare instance. Should this occur, the physician will order a specific volume of the bronchodilator to be added to the nebulizer (spray attachment) on a ventilator, and the patient will receive the drug by mouthpiece or mask.

### ENDOTRACHEAL

Some drugs, such as epinephrine and lidocaine, are very rapidly absorbed across the bronchial membrane—with a speed approaching that of IV administration. In some cases of cardiac arrest, you may be unable to start an IV and will need a physician's authorization to administer epinephrine or lidocaine through the endotracheal tube. If authorization is given, quickly remove the needle from the syringe and squirt the syringe's contents down the endotracheal tube. Then immediately reconnect the bag and ventilate the patient briskly, to facilitate passage of the medication down the trachea. Only epinephrine or lidocaine should be administered in this manner.

### SUBLINGUAL

Drugs taken sublingually, or under the tongue, generally are rapidly absorbed, and their effects are apparent within a few minutes. Nitroglycerin is administered in this fashion.

### ORAL

At home, most patients take their daily medications orally. Drugs taken orally are absorbed from the stomach and the intestine at a somewhat unpredictable, but generally slow, rate. Because absorption is slow and unpredictable, medicine is seldom administered orally in emergency situations. Two exceptions are syrup of ipecac, which is used to induce vomiting, and activated charcoal, which is used to absorb ingested poisons.

### RECTAL

Rectal administration is not usually used in the field. Certain medications—aminophylline, for example—are available in suppository or enema form, and under certain circumstances, you may have to administer them. Absorption across the rectal mucosa is rapid, although not entirely predictable.

### Intracardiac

Intracardiac administration is the direct injection of drugs through the chest wall into the heart. This route is sometimes used to administer epinephrine during cardiac arrest. Possible complications of intracardiac injection include laceration of a coronary artery, pneumothorax, and accidental injection into the cardiac wall muscle rather than into a cardiac chamber. If epinephrine is injected into the cardiac wall muscle, the medication may cause uncontrollable ventricular fibrillation.

The speed at which a drug is absorbed is related to the route by which it is given. Drugs injected directly into the circulation, as in IV and intracardiac injections, gain access to the circulation fastest. Nearly as rapid as absorption across the respiratory mucosa when drugs are sprayed down the endotracheal tube. Other mucosal surfaces, like that in the rectum, also provide rapid absorption, although some what variable in nature. The IM injection is a slower route than those previously mentioned, because the drug must be picked up from the muscle by the circulating blood. SC injections are absorbed even more slowly than those administered IM. In general, however, drugs administered orally have the slowest absorption rate of all.

Once a drug is absorbed, it is delivered to various target organs by the bloodstream. Over a period of time, the drug is inactivated (detoxified) by the body. The liver is the major organ involved in drug metabolism. Both kidneys and the gallbladder help concentrate drugs or drug metabolites (products of metabolism). Either the metabolized (inactivated) drug or the unchanged drug is eliminated from the body via the urine or the stool, although smaller amounts of some drugs are excreted through the lungs or sloughed off with dead skin cells.

## Terms Used to Describe the Nature of Drug Action

A variety of special terms are used to describe drugs and their actions:

- Depressant—A substance that lessens the activity of the body or any of its organs. Morphine, for example, is a respiratory depressant.
- Stimulant—A drug that increases the activity of the body or any of its organs. Caffeine and epinephrine are, respectively, nervous-system and cardiac stimulants.
- Physiologic action—Action caused by a drug when given in concentrations normally present in the body (applies only to drugs that are derived from normal body chemicals).
- Therapeutic action—Beneficial action of a drug that corrects a body dysfunction.
- Antagonism—Action that creates opposition or contrariety, as between muscles, medications, or organisms.
- Untoward reaction—Side effect of a drug regarded as harmful to the patient.
- Irritation—Action that produces slight or temporary damage to tissues.
- Cumulative action—Increased intensity of drug action evident after administration of several doses of a drug.
- Tolerance—Progressive diminution of susceptibility to the effect of a drug after repeated doses.
- Synergism—Joint action of drugs such that their combined effect is greater than the sum of their individual effects.

- Potentiation—Enhancement of the effect of one drug by another.
- Additive—Characterized by addition.
- Habituation—Where a drug's effects are necessary to maintain a person's feeling of well-being.
- Idiosyncrasy—An abnormal susceptibility to a drug that is unpredictable and peculiar to an individual.
- Hypersensitivity—Increased reactivity of an individual to contact with certain substances (allergy).

## Drugs Affecting Different Parts of the Body

Drugs affect the various organ systems of the body, such as the circulatory system or the digestive system, in different ways. Though far beyond the scope of this manual to describe in detail the full range of drug actions, indications, contraindications, side effects, and interactions, this material is readily available, however, in any standard pharmacology text, in the *PDR*, or in the patient package inserts available in most drug packages. In Appendix A, drugs commonly used in the field are briefly described, as are drugs commonly taken by patients at home. Each time you hear of or use a drug, refer to one of these sources. This will help build a solid working knowledge of pharmacology.

Appendix B discusses those drugs that, if taken regularly by a patient, may give you some clues to the patient's underlying medical problem. It is, therefore, especially necessary for you to understand these drugs.

## Drugs Affecting the Autonomic Nervous System

Drugs that affect the autonomic nervous system will be given special attention because their importance in the treatment of patients with cardiac conditions. The autonomic nervous system is chemical. The neurotransmitter chemicals, when administered in large or pharmacologic doses, are potent drugs.

Acetylcholine is the parasympathetic neurotransmitter. Vagus nerve endings on internal organs release acetylcholine into the organs. Vagal stimulation slows the heart rate; constricts the bronchi; increases peristalsis (motion) in the esophagus, small intestine, and colon; and increases gastric, intestinal, and pancreatic secretion.

Specific vagal effects on the heart include decreased heart rate due to fewer firings of the sinoatrial (SA) node, inhibit the atrial muscle's ability to contract, and slower conduction in the atrioventricular (AV) node. No vagal fibers reach the ventricle, and therefore, the parasympathetic division has no effect on the ventricles. (Drugs that mimic the effects of the parasympathetic division, however, can reach the ventricles via the bloodstream and inhibit the ability of ventricular muscle to contract). Other cranial parasympathetic nerves constrict the pupils and cause secretion from the lacrimal (tear) and salivary glands. Sacral parasympathetic nerves increase peristalsis in the distal colon and rectum and also produce defecation and urination.

### SYMPATHETIC NERVOUS SYSTEM

Norepinephrine, the sympathetic neurotransmitter, produces effects that nearly approximate the emergency actions (fight or flight). The parasympathetic nervous system is the collection of nerve centers, fibers, and chemical transmitters that controls automatic, or involuntary, activities. The importance of the autonomic nervous system can be gauged by considering what life would be like if all bodily functions were solely under voluntary control. Were this the case, an individual would have to consciously direct the heart to beat, the lungs to inflate, and the stomach to digest. Furthermore, with every change in the level of activity, such as with exercise, all the bodily functions would have to be altered to meet the demands of the new activity. Fortunately, the autonomic nervous system accomplishes the necessary control activities without any conscious effort on the part of the individual. The autonomic nervous system can be divided into the parasympathetic division, which controls vegetative functions such as digestion and heart rate, and the sympathetic division, which prepares the body for stressful situations and for vigorous muscular activity.

### PARASYMPATHETIC NERVOUS SYSTEM

The major parasympathetic nerves are the two vagus nerves (Cranial Nerve X) that travel, one on each side of the body, from nerve centers or nuclei in the medulla to the internal organs or viscera. (See Module 2.) Nerve cells are specialized to receive stimuli and to transmit stimuli to other nerves, muscles, or glands. Conduction along nerves is electrical, but transmission from one nerve to another or to end organs is opposite those of acetylcholine. To remember the effects of the sympathetic nervous system, think of the "fight or flight" response that prepares the body for stressful situations. The sympathetic system dilates the pupils, increases the heart rate and the force of cardiac contractions, inhibits the digestion and absorption of food, and produces sweating and hair to stand on end (piloerection). In addition, this system produces vasoconstriction in the skin, kidneys, and digestive organs, and vasodilation in skeletal muscle.

Specific sympathetic effects on the heart include an increased heart beat due to the increased SA node firing rate, an increased ability of the atrial muscle to contract and to conduct stimuli, an increased rate of conduction in the AV node, an increased ability of the left ventricle to contract, and an increased stroke volume. These effects increase cardiac output.

All blood vessels, except capillaries, are innervated by the sympathetic nervous system. Small arteries and arterioles, however, receive the largest number of sympathetic nerve fibers. All blood vessels that receive sympathetic nerve fibers constrict in response to sympathetic stimulation. In addition, some arterioles dilate when stimulated by sympathetic nerves.

In general, veins receive fewer sympathetic fibers than corresponding arteries. But the vasoconstriction of veins in response to sympathetic stimulation reduces the capacity of the vascular system.

Sympathetic effects can be divided into alpha and beta effects—effects produced by interaction of the neurotransmitter with alpha or beta receptors on the "end organs." Sympathetic stimulation of alpha receptors in blood vessels produces vasoconstriction; stimulation of beta receptors, vasodilation. The heart has only beta receptors, which increase the rate and force of cardiac contraction and produce the other aforementioned sympathetic effects. Stimulation of the beta receptor also relaxes smooth muscle in the bronchi and gastrointestinal tract.

Organs have varying proportions of alpha and beta receptors in their arterioles. Thus, sympathetic stimulation increases the blood flow in some organs and decreases it in others. Beta receptors predominate in coronary (heart) and skeletal muscle arterioles. In arterioles in the brain and lungs, alpha and beta receptors are present in approximately equal numbers. Alpha receptors predominate in arterioles in the skin, kidneys, and digestive organs. Thus, sympathetic stimulation causes vasodilation (beta effect) or vasoconstriction (alpha effect) in the lungs and brain and vasoconstriction in the skin, kidneys, and digestive organs. (See Table 4.1.)

**Table 4.1.—Alpha and Beta Effects for Various Parts of the Body**

| Body part | *Effects* | |
|---|---|---|
| | *Alpha* | *Beta* |
| Heart | None | Increased rate, increased force, increased automaticity |
| Arterioles | Constriction | Dilatation |
| Lungs | None or mild bronchoconstriction | Bronchodilation |

Neurotransmitters and drugs resembling neurotransmitters are classified according to the alpha and beta effects they produce. Norepinephrine activates all alpha and some beta receptors. Epinephrine activates all alpha and all beta receptors. Two drugs that mimic sympathetic agents (sympathomimetic drugs) and have only alpha effects are phenylephrine (Neo-Synephrine) and methoxamine (Vasoxyl). A commonly used drug with only beta effects is isoproterenol (Isuprel). Based on their alpha and beta effects, these drugs can be pictured along a continuum as shown in Figure 4.1.

There are drugs that block the effects of parasympathetic or sympathetic stimulation by occupying the chemical receptor sites on end organs and displacing sympathetic or parasympathetic neurotransmitters. Atropine, for example, blocks the effects of acetylcholine released from postganglionic parasympathetic neurons by attaching itself to the acetylcholine receptor site on the effector organ. Atropine is selective, attaching itself only to receptor sites on effectors. It has little effect on impulse transmission by acetylcholine in autonomic ganglia. By blocking parasympathetic effects on the heart, atropine increases heart rate and cardiac output despite excessive parasympathetic stimulation.

Specific alpha- and beta-adrenergic blocking agents also exist. Alpha blockers include phentolamine (Regitine) and phenoxybenzamine (Dibenzyline). A commonly used beta-blocking agent is propranolol (Inderal). Phentolamine and phenoxybenzamine block vasoconstriction; propranolol blocks several beta effects, including vasodilation, cardiac acceleration, increased force of cardiac contraction, and relaxation of smooth muscle in the bronchi and gastrointestinal tract. Propranolol can be used to slow rapid heart rates and to reduce blood pressure in certain critical clinical situations.

## Important Things to Understand and Look for When Studying a Drug

Before using any drug in the field, you must answer the following questions:

- What are the therapeutic effects of the drug? That is, what is the desired effect that the drug should produce?
- What are the indications for the drug? That is, for what condition(s) is the drug properly used?
- What precautions should be taken? How should the patient be monitored after drug administration?
- What are the contraindications to use of the drug? That is, under what circumstances should the drug not be used?
- Given the patient's age and weight, what is the correct dosage of the drug?

- What side effects may be expected secondary to the drug? Side effects are to be distinguished from allergic or idiosyncratic reactions. Side effects are predictable but undesirable effects that occur in addition to the drug's therapeutic effects. Allergic reactions are largely unpredictable—unless the patient has had an allergic reaction to the same drug before—and may lead to life-threatening anaphylaxis. Allergic reactions should be anticipated with any drug, whereas side effects are usually fairly specific for a given drug.
- What is the correct mode of administration? Drugs can be administered by a variety of methods, but remember that a drug can be therapeutic when administered by one route and lethal when given by another.

## Summary

The human nervous system consists of a voluntary and an involuntary system. The latter, also called the autonomic nervous system, is further divided into the parasympathetic and sympathetic nervous systems.

The parasympathetic system controls vegetative functions. By the release of acetylcholine, the parasympathetic system is mediated mainly through the vagus nerve. Vagal stimulation slows the heart. This action can be opposed by atropine, the parasympathetic blocker.

The sympathetic nervous system enables the body to respond to stress. It is mediated on the release of norpinephrine, by the nerves arising in the thoracic and lumbar ganglia, and on the release of epinephrine, by the adrenal gland. Sympathetic agents are classified as alpha or beta.

Alpha agents have no direct effect on the heart. They have minimal bronchoconstricting effect, but significant vasoconstricting action. Metaraminol (Aramine) and norepinephrine (Levophed) may be used as alpha agents in the field to increase blood pressure. Both of these drugs, however, have some beta effects as well.

Beta agents cause the heart to increase its rate and the force of its contraction. Overall myocardial (heart muscle) irritability is increased by these agents, which also dilate arteries and bronchi. Isoproterenol (Isuprel) and epinephrine (Adrenalin) are beta agents frequently used in the field to stimulate the heart. Isoproterenol has only beta effects, but epinephrine stimulates alpha receptors as well as beta receptors.

Sympathetic blockers occupy receptor sites and prevent sympathetic stimulators from acting. Because propranolol is a beta blocker, it slows the heart and prevents vasodilation and bronchodilation.

The uses of the various drugs described below can be inferred by their properties.

**Atropine** is a parasympathetic blocker that opposes the vagus nerve. Hence atropine is used to speed up the heart when excess vagal stimulation has caused slow heart rate (bradycardia).

**Norepinephrine** is a sympathetic agent that produces mainly alpha effects, but also some beta effects. It vasoconstricts blood vessels by acting on alpha receptors. Norepinephrine can, therefore, be used to increase the blood pressure when hypotension is caused by vasodilation, as occurs in shock.

**Isoproterenol** is a sympathetic beta agent that causes increased heart rate and bronchodilation. It is used to increase cardiac output and to dilate bronchi in asthma.

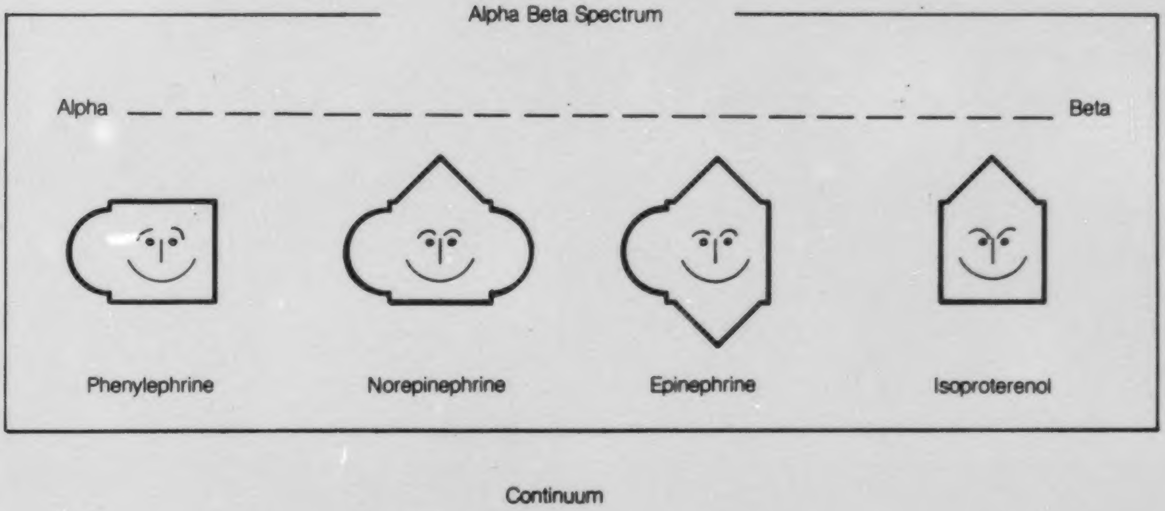


**Figure 1. Various Drugs on a Continuum from Alpha Blockers to Beta Blockers**

**Epinephrine** is a sympathetic agent with both alpha and beta effects. Its actions resemble those of isoproterenol, but also include mild vasoconstriction. Because epinephrine increases the automatic activities of the heart, it is used in the treatment of asystole—fine ventricular fibrillation—and anaphylactic shock.

**Propranolol** is a sympathetic beta blocker. It is used to slow the heart rate in certain tachyarrhythmias (irregular, rapid heart rate) to decrease the pain of angina by decreasing the work of the heart, and to depress ectopic foci in the heart by decreasing its automatic action.

## Unit 3. Weights and Measures

To determine the correct dosages of drugs, you must understand their units of measurement. Two systems of measurement are applicable to drug therapy. The first, the apothecary system, the older of the two, is seldom used anymore. The apothecary system measures solids in grains, drams, ounces, and pounds and liquids in minims, fluidrams, ounces, pints, and gallons.

The second system, the metric system, is more frequently used in official listings of drugs and, therefore, is the system to be used herein. The metric system is logical and simply organized. The primary unit of weight in the metric system is the gram (g), and the primary measure of volume of liquid is the liter (l).

Units in one system can be converted to the other. The conversions, however, are usually only approximations. Some common conversions are listed in Table 4.2.

The only conversion that you, the paramedic, are likely to make in the field is one from pounds (apothecary) to kilograms (metric). Most patients will give their weight in pounds, but many dosages are calculated on the basis of weight or volume per kilogram of body weight. To convert pounds to kilograms, simply divide the body weight in pounds by 2.2:

$$\text{weight in kilograms} = \frac{\text{weight in pounds}}{2.2}$$

Thus, a 150-pound man would weigh approximately 70 kg.

**Table 4.2.—Common Measurement Conversions**

**Metric to Apothecary**

| Metric | Apothecary |
|---|---|
| 1 ml | 15 minims. |
| 10 ml | 2.5 fluidrams. |
| 100 ml | 3.5 fluidounces. |
| 1,000 ml (1 l) | 1 quart. |
| 1 g | 15 grains. |
| 10 g | 2.5 drams. |
| 100 g | 3.3 ounces. |
| 1,000 g (1 kilogram) (kg) | 2.2 pounds. |

**Apothecary to Metric**

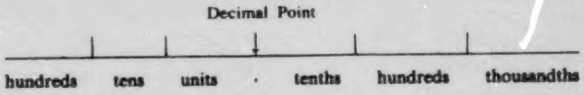
| Apothecary | Metric |
|---|---|
| 1 minim | 0.06 ml. |
| 1 fluidram | 4 ml. |
| 1 fluidounce | 30 ml. |
| 1 pint | 500 ml. |
| 1 quart | 1,000 ml (1 l). |
| 1 grain | 60 mg. |
| 1 dram | 4 g. |
| 1 ounce | 30 g. |
| 1 pound | 500 g. |

### A Review of Decimals

The metric system is based on multiples or derivatives of 10, in other words, the decimal system.

It is necessary, therefore, for you to be able to work easily with the decimal system. Decimals consist of a whole number (the number before the decimal point), a decimal point, and a decimal fraction (the number after the decimal point): 4.06

The position of the number in relationship to the decimal point gives the number its place name. For example, one place to the right of the decimal point is called "tenths;" two places to the right is called "hundredths" and so on.



For example:

$$.6 = \text{six-tenths} = 6/10$$
$$.07 = \text{seven-hundredths} = 7/1000$$
$$.008 = \text{eight-thousandths} = 8/1,000$$

To eliminate any confusion that might arise from overlooking the decimal point and reading the decimal fraction as a whole number, a zero should be placed to the left of the decimal when there is no whole number (the decimal fraction, "fourteen hundredths," is written 0.14). Adding zeroes to the right of the decimal fraction does not change its value:

$$0.5 = 0.50 = 0.500$$
$$5/10 = 50/100 = 500/1,000$$

*To add and subtract decimals,* the decimal points should be lined up and zeroes should be added to the right of the decimal fraction:

Example—addition 1.5 + 21.65
$$\begin{array}{r} 1.50 \\ +\ 21.65 \\ \hline 23.15 \end{array}$$

Example—subtraction 23.15 − 1.5
$$\begin{array}{r} 23.15 \\ -\ 1.50 \\ \hline 21,65 \end{array}$$

Multiplication of decimals is carried out in exactly the same fashion as multiplication of whole numbers, except for the placing of the decimal point in the product. To do this, count the number of decimal places in the numbers to be multiplied, and then to locate the decimal point, count the same number of places from the right of the product.

$$\begin{array}{r} 125 \\ \times .5 \\ \hline 62.5 = \text{product} \end{array} \qquad \begin{array}{r} 12.5 \\ \times .5 \\ \hline 6.25 = \text{product} \end{array}$$

$$\begin{array}{r} 1.25 \\ \times .5 \\ \hline .625 = \text{product} \end{array} \qquad \begin{array}{r} .125 \\ \times .5 \\ \hline .0625 = \text{product} \end{array}$$

When multiplying by 10, the decimal point should be moved one place to the right.

$$\begin{array}{r} 12.5 \\ \times 10 \\ \hline 125.0 \end{array} \qquad \begin{array}{r} .125 \\ \times 10 \\ \hline 1.250 \end{array}$$

When multiplying a decimal by 100, move the decimal point two places to the right.

$$\begin{array}{r} 12.5 \\ \times 100 \\ \hline 1250.0 \end{array} \qquad \begin{array}{r} 1.25 \\ \times 100 \\ \hline 125.0 \end{array}$$

Thus, when multiplying a decimal by a multiple of 10, the decimal point should be moved to the right by the number of zeroes found in the multiple of 10. For example, 1,000 has three zeroes. If 1.25 is multiplied by 1,000, the decimal point is moved three places to the right, obtaining a product of 1,250.

Dividing decimals is no different than dividing whole numbers, except that the decimal point must be considered. The terminology of division should be recalled: In the problem 24 divided by 6 = 4, 24 is the dividend, 6 is the divisor and 4 is the answer or quotient. With decimals (except when the dividend is a decimal) the decimal point is kept in the quotient above the decimal point in the dividend.

$$\begin{array}{r} .6 \\ \hline 4/2.4 \end{array}$$

The divisor must always be a whole number. Thus, in the problem,

$$\begin{array}{r} .6 \\ \hline 4/2.4 \end{array}$$

.4 should be made into a whole number by moving the decimal point one place to the right. Do not move the decimal point in the divisor without moving the decimal point in the dividend the same number of places. Thus, 2.4 becomes 24.0 and the problem becomes:

$$\begin{array}{r} 6.0 \\ \hline 4/24.0 \end{array}$$

The decimal point in the quotient should be kept above the new location of the decimal point in the dividend. The rule for dividing decimals by multiples of 10 is the inverse of the rule for multiplication: The decimal point should be moved to the left by the number of zeroes in the divisor. For example:

$$\begin{array}{r} 0.5 \\ \hline 10/5.0 \end{array} \qquad \begin{array}{r} 0.05 \\ \hline 100/5.0 \end{array} \qquad \begin{array}{r} 0.005 \\ \hline 1,000/5.0 \end{array}$$

## Metric Units

The secondary unit of weight in the metric system is the milligram (mg). "Milli" means "thousandths," and, therefore, a milligram is one-thousandth of a gram (there are 1,000 mg in 1 g).

$$\frac{1}{1,000}\ \text{g} = 0.001\ \text{mg}$$

To convert grams to milligrams, multiply the number of grams by 1,000, which has the same effect as moving the decimal point three places to the right. Conversely to convert milligrams to grams, divide the number of milligrams by 1,000, which is the same as moving the decimal point three places to the left.

$$2,000\ \text{mg} = \frac{2,000}{1,000}\text{g} = 2\ \text{g}$$

Suppose a physician orders 1,000 mg of a certain drug and that drug is dispensed in 0.5=g tablets. To determine the number of tablets to be given, first convert milligrams to grams. Then divide the desired dose (1 g) by the concentration in the tablets (0.5 g). The dividend is the number of tablets to be given: two.

$$1.0\ \text{g} \div 0.5\ \text{g} = 2\ \text{g}$$

Units of volume, or liquid measure, in the metric system are also based on decimal fractions. The secondary unit of volume is the milliliter (ml). A milliliter is one-thousandth of a liter (there are 1,000 ml in 1 l).

$$\frac{1}{1,000}\ \text{l} = 0.001\ \text{l} = 1\ \text{ml}$$

To convert liters to milliliters, multiply the number of liters by 1,000, which has the same effect as moving the decimal point three places to the right. Conversely to convert milliliters to liters, divide the number of milliliters by 1,000, which is the same as moving the decimal point three places to the left.

$$\frac{3{,}000\ \text{ml}}{1{,}000} = 3{,}000\ \text{l} = 3\ \text{l}$$

Another measure you may possibly encounter is the cubic, or double, centimeter (cc). One milliliter of water weighs 1 g and occupies 1 cc of space. Thus, a milliliter and a cubic centimeter both express one-thousandth of a liter and can be considered equivalent expressions.

### Drug Concentrations (Liquids)

Proper dosage of a drug depends on its proper concentration—that is, how many milligrams of the drug are contained in a milliliter of liquid. For example, suppose you are instructed to administer 20 mg of a drug that is supplied in a concentration of 10 mg/ml. How many milliliters should be given? The general formula for determining the proper dosage is:

$$\frac{\text{desired dose}}{\text{concentration on hand (mg/ml)}} = \text{milliliters to be administered}$$

In this problem, the desired dose is 20 mg and the concentration on hand is 10 mg/ml. Therefore:

$$\frac{20\ \text{mg}}{10\ \text{mg/ml}} = 2\ \text{ml}$$

## Unit 4. Administration of Drugs

The decision to order the administration of any drug is a complex one, involving the patient's age, signs, symptoms, overall condition, allergic history, concomitant medical problems, present medication, and other considerations. Therefore, the physician must be supplied with thorough and accurate clinical information in order to make the appropriate decisions about drug therapy. In the field, there is no room for error in life-threatening situations that require drug administration.

A paramedic may administer medication only on the order of a licensed physician. If that order is unclear or seems to be mistaken—the dose is above the usual range; the route of administration is unusual—ask the physician to repeat the order. Do not assume that the physician is infallible. Never guess. When in doubt, ask.

To guard against error in communication, repeat over the radio any order that the physician has given to confirm that it has been received accurately. Include in the repetition: the name of the drug, the dose, and the route by which it is to be given. You are as much responsible for the administration of the drug and its possible consequences as the physician giving the order. Be absolutely certain of what you are administering and why. Medication labels should be read as the vials are removed from the box and, again, before the drug is administered. Check the label for the drug's concentration and expiration date. Never use the contents of unlabeled containers.

Check any fluid to be sure that it has not precipitated.

When giving more than one drug, make certain that they are not incompatible. Some drugs will not mix with others: For example, if sodium bicarbonate is mixed with calcium chloride, an insoluble precipitate of calcium carbonate will form.

After drawing the drug from the vial, check the volume of the dose once again with the physician. ("I have 2 ml of Valium at 5 mg per ml . . .") Administer the drug aseptically. (This will be described in the next unit.)

Should cloudiness occur after a drug has been injected into IV tubing, clamp the tubing immediately, stop the infusion, and change the tubing.

## Unit 5. Techniques of Administration (Skills)

The various techniques for administering drugs will be discussed in this unit. To be summarized are the proper procedures for drawing medications from vials and ampules, for performing intravenous, intramuscular, subcutaneous, and intracardian injections, and for adding medications to IV bottles.

### Syringes and Scales

Syringes are necessary for administering all parenteral medications. A syringe has three parts: the barrel, the plunger, and the hub.

All syringes used by paramedics have scale markings on the barrel. Syringes come in different sizes—commonly 2, 5, 10, 20, and 25 cc—and, thus, have different scales.

Although reusable glass syringes are acceptable in the hospital setting, disposable plastic syringes are used in the field almost exclusively. Prepackaged sterilized syringes, with attached needles or without, are commercially available and are convenient and easy to use. Become familiar with their use if they are standard equipment in your area.

### Drawing Solutions From a Vial or Ampule

Most medications for parenteral injection are supplied in vials, ampules, or prefilled syringes. You must learn to handle these containers quickly and with aseptic techniques. To draw medications from a vial or an ampule into a syringe:

- Prepare a syringe of the appropriate volume with a needle of the appropriate gauge. (See the subsequent sections on IV, IM, and SC injections.)
- Check the vial or ampule to make sure that the medication is correct and to determine the concentration (mg/ml) of the drug.
- Compute the desired volume of the medication.
- Clean the vial's rubber stopper with an alcohol wipe. When using an ampule, lightly tap or shake the ampule to dislodge any solution from its neck. Score the ampule's neck with a file—that is, unless the ampule's neck is circled by a colored line, indicating that it is prerecessed—and place an alcohol sponge around the neck. Now break off the neck, being careful to avoid the resulting sharp glass edges.
- Before withdrawing a solution from a vial, pull air into the syringe in a volume equal to that of the solution to be withdrawn. Insert the needle through the rubber stopper, and inject the air into the vial. Then invert the vial and withdraw the desired amount of solution. When using an ampule, carefully insert the needle into the solution without allowing it to touch the edges of the ampule and draw the solution into the syringe.
- Check again both the label on the vessel and the dosage of medication to be withdrawn.
- Protect the needle from contamination until use.

## Use of a Prefilled Syringe

The most convenient form of medication in the field is the prefilled syringe, which eliminates the drawing of a calculated dose from a vial or ampule, thus saving time and reducing the possibility of error. Most emergency drugs, including epinephrine, atropine, lidocaine, calcium, sodium bicarbonate, 50 percent dextrose, and diazepam (Valium), are supplied by commercial drug manufacturers in this form. Like any other drugs, medications supplied in prefilled syringes must be administered with care and precision. To use a prefilled syringe:

- Check the label on the medication cartridge for drug name and concentration. Note the gradations and total volume of the syringe.
- Calculate the desired volume of medication.
- With your thumbs, pop off the protective caps of the syringe barrel and the medication cartridge.
- Screw the medication cartridge into the syringe barrel.
- Before administering medication, remove all residual air from the syringe. Point the needle of the syringe at the ceiling and depress its plunger until all air has been evacuated. Next, evacuate all medication but the desired volume from the syringe. This prevents accidental injection of the entire cartridge, when it is necessary to inject only part of the contents.
- If medication is to be given by IV push or bolus, pinch off the IV tubing above the injection site, clean the rubber adapter on the IV tubing, and insert the needle. Slowly inject the desired amount into the IV tubing. When the dose has been delivered, unclamp the tubing and allow sufficient flow to carry the medication through the tubing into the patient's vein.

## Addition of Drugs to IV Bottle or Bag

Certain drugs are added to the IV solution itself, rather than being administered directly to the patient. This is especially true of drugs whose effects must be carefully titrated—norepinephrine or lidocaine when given as a drip. When adding medication to an IV bag or bottle:

- Set up the IV bag and tubing in the usual manner.
- Check the drug name on the vial, ampule, or prepackaged syringe. Check the drug's concentration.
- Compute the volume of the drug to be added to the IV bottle or bag. Remember that when you add a large volume of a drug to an IV bag or bottle, the additional volume must be considered as part of the final total volume. For example, if a solution containing 1 g (1,000 mg) of a drug in a 100-ml solution is added to an IV bag containing 900 ml of 50 percent dextrose (D5W), the total volume is 1,000 ml. Therefore, the drug concentration will be:

$$\frac{1{,}000 \text{ mg}}{1{,}000 \text{ ml}} = 1 \text{ mg/ml}$$

If the drug solution is not concentrated enough to give the desired result when added to the smallest IV solution container, plan to withdraw solution from the bag before mixing in the drug. For example, suppose only one prefilled syringe containing 50 ml of 10 mg/ml solution is available, and the order is given to administer a 2 mg/ml solution. A 50 ml amount of an 10 mg/ml solution contains:

$$50 \text{ ml} \times 10 \text{ mg/ml} = 500 \text{ mg of the drug}$$

To obtain a 2 mg/ml solution, the paramedic must calculate a final solution volume:

$$\text{volume} = \frac{\text{drug weight}}{\text{desired concentration (weight/volume)}}$$

$$= \frac{500 \text{ mg}}{2 \text{ mg/ml}} = 250 \text{ ml}$$

If the smallest IV bag contains 500 ml D50W, enough solution must be withdrawn to make a final volume of 250 ml. In this case, you would need to withdraw 300 ml D50W leaving only 200 ml D50W in the bag. Adding the 50 ml solution then gives a total volume of 250 ml. You should:

—Draw up the computed amount in a syringe. If a prefilled syringe is used, note the volume of the solution to be used.

—Clean the gum rubber stopper or sleeve on the IV bottle or bag with an alcohol swab.

—Puncture the stopper or sleeve with the needle and inject the desired volume of medication into the bottle or bag. If the volume of medication that must be added will not fit in the IV bag or bottle, withdraw enough IV solution so that it will fit. Then inject the medication.

—Withdraw the needle and discard.

—Label the bottle or bag with the name of the medication added, the amount added, the resultant concentration of medication, the time at which the medication was added, the date, and your initials (Lidocaine, 500 mg added, concentration now 2 mg/ml, 1100, 9/25/76, JSS).

—Calculate the rate at which the IV must run (drops per minute) to deliver the desired dose of medication. Suppose you need to prepare 250 ml of a 2 mg/ml lidocaine solution in D5W that is to be given by continuous IV drip. Lidocaine is available for intravenous administration in a 20 mg/ml solution. To determine how much of this solution is needed, first multiply the desired concentration by the desired volume:

$$250 \text{ ml} \times 2 \text{ mg/ml} = 500 \text{ mg}$$

—Divide the weight needed by the concentration of the original solution:

$$\frac{500 \text{ mg}}{20 \text{ mg/ml}} = 25 \text{ ml of } 20 \text{ mg/ml solution}$$

—Withdraw 25 ml D5W from the IV bag and inject the calculated amount—25 ml of 20 mg/ml solution.

## The Subcutaneous Injection

The SC injection is used in the field primarily for the administration of epinephrine to patients with moderately severe asthmatic or allergic reactions. To perform an SC injection use this technique:

- Check the label on the medication, compute the dosage, and draw up the desired volume in the syringe. For SC injection, the syringe should be equipped with a 25-gauge needle.
- Select a site for injection. Generally the skin overlying the deltoid muscle is the most accessible, although the anterior thigh can also be used.
- Clean the site with iodine or alcohol wipes, using a circular motion going from the anticipated injection site outward.
- Remove the cap from syringe needle. Point the needle at the ceiling, and depress the plunger until any residual air has been expelled from the barrel.
- Gently grasp the skin over the injection site and pull it away from the underlying muscle. Insert the needle with the bevel up well into the subcutaneous tissues at a 45 degree angle to the skin.
- Pull back slightly on the plunger to be certain a blood vessel has not been entered. If there is blood return, pull the needle back slightly until blood return ceases. If there is no blood return, inject the contents of the syringe at a slow, steady rate.
- Withdraw the needle smoothly, at the same angle at which it was inserted, and apply pressure over the injection site with a wipe.
- Dispose of contaminated equipment.

## The Intramuscular Injection

The IM injection is not often used in the field, although in some locations morphine and lidocaine are administered to well-perfused patients by this route. Use this technique to administer an IM injection:

- Check the label on the medication container, compute the dosage, and draw up the desired volume in the syringe. For intramuscular injection, the syringe should be equipped with a 21-gauge needle. Use a 1½-inch-long needle for adults and a ⅝-inch-long needle for children.
- Select a site for injection. Again, the deltoid is the most accessible, although the upper outer quadrant of the gluteus muscle can also be used. The deltoid muscle can only be used for injection volumes of less than 2 ml. The gluteus muscle will accept up to 10 ml, but the injection must be made in the upper outer quadrant to avoid injection into the sciatic nerve or superior gluteal artery, which runs more medially.
- Clean the site with iodine or alcohol swabs.
- Remove the protective cap from the needle, and evacuate any air from the syringe.
- Stretch the overlying skin taut with two fingers.
- Insert the needle at a 90 degree angle to the skin.
- Pull back slightly on the plunger to ascertain that no blood vessel has been entered. If there is blood return into the syringe, withdraw the needle slightly until blood return stops. If there is no blood return, inject the contents of the syringe at a slow, steady rate. If, during the injection, the patient complains of pain radiating down his or her leg into the gluteal region, stop the injection immediately.

- Remove the needle smoothly at the same angle at which it was inserted, and apply direct pressure over the injection site.
- Dispose of contaminated equipment.

## Intracardian Injections

Intracardian injections can be used to administer epinephrine or calcium chloride during cardiac arrest. The possible complications of this technique are coronary artery laceration, injection into the heart muscle, pneumothorax, and cardiac tamponade. Use the following technique when performing intracardian injection:

- Check the label on the medication container, compute the dosage, and draw up the desired volume in a syringe. Connect a 10-cm (spinal) needle to the syringe.
- Locate, for injection, the fourth or fifth intercostal space or the area to the left of the xiphoid process. The risk of pneumothorax is greatest when you inject in an intercostal space; the risk of coronary artery damage is greatest when you inject near the xiphoid.
- Clean the selected area with an alcohol or iodine swab. Insert the needle into one of the following areas:

—**Fourth left intercostal space.** Direct the needle to the left of the sternum, posteriorly and medially.

—**Fifth left intercostal space.** Direct the needle to the left of the sternum at a 70 degree to 80 degree angle with the skin, medially and toward the head.

—**Left of the xiphoid process.** Direct the needle slightly to the left of the xiphoid process at a 45 degree angle to the skin. Direct the needle toward the right sternoclavicular joint.

- Pull slightly on the plunger as the needle is inserted.
- When blood is freely aspirated, inject the syringe contents.
- Rapidly withdraw the needle and resume external cardiac compression.

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# APPENDIX A

## DRUGS COMMONLY USED IN THE FIELD

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Sodium Bicarbonate. | Combines with hydrogen ions to raise pH; $HCO_3 + H^+ \rightarrow H_2CO_3 \rightarrow H_2O + CO_2$. | Neutralizes acid and returns the blood toward its normal physiologic composition; sodium bicarbonate enhances the effects of sympathomimetic agents on the heart. Agents produced by the body (and those injected into the body) are both affected. Given in conjunction with epinephrine, it enhances the effectiveness of defibrillation. | 1. To treat acidosis as occurs in shock, cardiac arrest, and certain poisonings.<br>2. To treat hyperkalemia (high potassium). | 1. Low serum potassium (sometimes detectable by large, prominent P waves and large U waves on the EKG).<br>2. Conditions in which the patient cannot tolerate a salt load, such as severe congestive heart failure. | 1. Because each mEq of bicarbonate also contains a mEq of sodium, bicarbonate has the same effect as any sodium infusion; i.e., it increases vascular volume. (In this respect, giving one syringe of bicarbonate is equivalent to giving about 300 ml of normal saline; 3 syringes of bicarbonate give the same amount of salt as a liter of normal saline.) Patients in CHF tolerate such salt loads poorly.<br>2. Administration of sodium bicarbonate lowers serum potassium. On some occasions, this is a desirable effect, as when bicarbonate is used intentionally to lower a dangerously high serum potassium level. However, in cardiac patients, if potassium falls too low, the heart becomes more irritable—especially if the patient is taking digitalis. | Supplied in premeasured syringes containing 50 mEq in 50 ml.<br>The dose is about 1 mEq (1 ml) per kg of body weight. In adults in cardiac arrest, one usually gives 50–100 mEq of bicarbonate initially, followed by an additional 50 mEq for every 10 minutes of arrest, up to a total of about 250 mEq (ml).<br>Effective ventilation must accompany the administration of sodium bicarbonate in order to blow off the excess carbon dioxide generated in the blood.<br>Sodium bicarbonate is given by the IV route only. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Morphine Sulfate... | Depresses sensory area of cerebral cortex (painful stimuli continue to be received by the cerebral cortex but are no longer interpreted as pain); decreases acute pulmonary edema, probably by reducing venous return. | Decreases pulmonary edema; helps to allay the anxiety associated with pulmonary edema. Morphine is a potent analgesic, providing significant relief of pain from AMI or trauma. | 1. To treat pulmonary edema.<br>2. To relieve pain in miocardial infarction and other circumstances. | 1. Marked hypotension.<br>2. Respiratory depression, except that due to pulmonary edema, where the drug may be used if ventilatory support is provided.<br>3. Asthma, chronic obstructive lung disease.<br>4. In patients who have taken other depressant drugs, such as alcohol or barbiturates. | 1. Hypotension.<br>2. Increased parasympathetic (vagal) tone, leading to bradycardia; can be treated with atropine.<br>3. Respiratory depression.<br>4. Nausea and vomiting.<br>5. Urinary retention. | Can be given by IV titration. The contents of a tubex (10 mg) is injected into a 10 ml syringe, and the remainder of the syringe (9 ml) is filled with D5W from the IV bag. 2–4 ml of this solution is given slowly IV every 5–30 min, as needed, with frequent monitoring of BP. Can also be injected. IM and SC routes not recommended in AMI. |
| Calcium Chloride .. | Maintains rhythm, tone and contractility of the heart; opposes toxic effect of excess sodium on the heart; opposes inhibitory action of potassium on the heart. | Increases myocardial contractility; enhances excitability, thereby increasing heart rate and cardiac output. | 1. To treat electromechanical dissociation, when there are regular ventricular complexes on the EKG but no pulse accompanying them.<br>2. To stimulate the heart to beat during asystole when epinephrine and bicarbonate have been ineffective.<br>3. To improve the strength of cardiac contractions after arrest if cardiac output remains depressed. | 1. Should be given with great caution, or not at all, to patients taking digitalis.<br>2. Should not be given together with sodium bicarbonate since it will form an insoluble precipitate.<br>3. Should not be given in the presence of coarse ventricular fibrillation. | When given to a patient who has been taking full doses of digitalis or when given too rapidly, calcium can cause sudden death from ventricular fibrillation. Given under appropriate circumstances, there are no side effects. | The usual dose of calcium chloride is 5 ml of a 10% solution given slowly IV. This may be repeated at 10 minute intervals. If calcium gluconate is used, the dose is 10 ml given slowly IV. If calcium gluceptate is used, the dose is 5 ml slowly IV. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Norepinephrine (Levophed, Levarterenol). | Stimulates all alpha- and some beta-adrenergic receptors. Alpha-adrenergic effects include vasoconstriction in the skin, stomach, intestines, pancreas, liver, and kidneys. Beta-adrenergic effects include increased heart rate and increased force of cardiac contraction. Alpha-adrenergic vasoconstriction, however, increases total peripheral resistance enough that cardiac output decreases in spite of cardiac stimulation. | Chiefly an alpha-sympathetic agent; therefore, increases BP by constricting arteries. It also has some beta activity, although less than epinephrine and thus has some effect in increasing the strength and rate of cardiac contractions. | To increase blood pressure in hypotension due to neurogenic or cardiogenic shock. | Hypotension resulting from hypovolemia, as in blood loss or dehydration. | 1. Necrosis of tissue surrounding the IV can occur if the IV infiltrates or the norepinephrine solution leaks out of the vein. For this reason, the IV should be checked closely before a norepinephrine drip is hung; an IV in a large vein (such as the antecubital) is preferred. Avoid hand veins for norepinephrine infusions.<br>2. Within the therapeutic range, there are few other side effects of norepinephrine. However, if the IV is inadvertently speeded up and the patient receives more than 4 μg/min, severe headache, sweating, nausea, vomiting, anxiety, ventricular arrhythmias, and serious hypertension may result. Watch the IV carefully and recheck the rate of administration often. | Administration by infusion prepared by adding 8 mg norepinephrine to 500 ml D5W yielding a concentration of 16 μg/ml.<br>Run at 0.5–1.0 ml/min (30–60 microdrops per minute) as needed to maintain systolic blood pressure above 90 mmHg. The infusion should never be left unattended; check and recheck blood pressure. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Metaraminol (Aramine). | Acts directly on alpha- and beta-adrenergic receptors. | Effects are midway between those of epinephrine and norepinephrine. Metaraminol has some of the beta properties of epinephrine, thus producing increased rate and force of cardiac contractions as well as some of the alpha properties of norepinephrine, with resulting vasoconstriction. It is used as an alternative to norepinephrine when a milder vasopressor is desired. | To increase blood pressure in hypotendue to neurogenic or cardiogenic shock. | Hypotension resulting from hypovolemia, as in blood loss, or dehydration. | Essentially the same as for norepinephrine.<br>Infusion outside the vein causes local tissue necrosis.<br>Overdose leads to sweating, headache, arrhythmias, etc. | Administered by infusion prepared by adding 100 mg (10 ml) of the drug to 250 ml of D5W, yielding a concentration of 0.4 mg/ml. This infusion is then titrated with a microdrip, at rates starting at 20–30 drops/min until systolic pressure reaches at least 100 mmHg. At this point, the infusion rate is maintained constant, with frequent checks on BP and adjustments up or down of the infusion rate as needed. |
| Bretylium tosylate (Darenthin). | Adrenergic blocking action. Positive inotropic effect on myocardium. | Effects the facilitation of termination of ventricular fibrillation by electrical shock. Maintains cardiac output and does not depress cardiac function. | Antiarrhythmic agent to be used in treating ventricular tachycardia and ventricular fibrillation that have been unresponsive to other forms of therapy. | Not considered a first-line antiarrhythmic agent. | Postural hypotension, nausea and vomiting, vertigo, and syncope have been reported. | In ventricular fibrillation, 5mg/kg is given as an IV bolus followed by electrical shock. If fibrillation persists, the dose can be increased to 10 mg/kg and repeated at 15–30 minute intervals to a maximum dose of 30 mg/kg. For recurrent ventricular tachycardia, 500 mg is diluted to 50 ml and abolus of 10 mg/kg injected IV over 8–10 min. After this loading dose, an infusion can be administered at a rate of 1–2 mg/min. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Epinephrine (Adrenalin). | Acts at both alpha- and beta-adrenergic receptors; alpha-adrenergic effects include vasoconstriction in arterioles of skin, kidneys, stomach, intestines, liver, and pancreas. Beta-adrenergic effects include vasodilation in heart and skeletal muscle, increased force of cardiac contraction, bronchodilation, and relaxation of nonvascular smooth muscle in the gastrointestinal tract. | 1. In cardiac arrest, may restore electrical activity in asystole. Increases myocardial contractility, decreases the threshold for defibrillation, via its actions as a beta-sympathetic stimulator. Thus, the heart is made to contract faster and more forcefully. Also elevates perfusion pressure partly via alpha effects.<br>2. In anaphylaxis, acts chiefly as a bronchodilator via beta action and maintains BP via alpha effects.<br>3. In asthma, causes bronchodilation. | 1. In cardiac arrest, to restore electrical activity and to enhance defibrillation in ventricular fibrillation. Also to elevate systemic vascular resistance and thereby improve perfusion pressure during resuscitation.<br>2. To treat the life-threatening symptoms of anaphylactic shock.<br>3. To treat acute attacks of asthma. | Must be used with great caution in patients with angina, hypertension, hyperthyroidism. There are no contraindications to the use of epinephrine in the situation of cardiac arrest or anaphylaxis. | In the conscious patient, may cause palpitations due to tachycardia or ectopic beats, elevation of blood pressure (which may not be desirable if the patient is already hypertensive), headache. The asthmatic with preexisting heart disease may experience dysrhythmias on treatment with epinephrine. | 1. In cardiac arrest in adults, a dose of 5 ml of a 1:10,000 solution should be administered IV at approximately 5-min intervals. In children, the dose is 0.1 ml/kg of a 1:10,000 solution (this is the concentration found in a prefilled syringe).<br>2. In mild anaphylactic reaction, 0.5 ml of a 1:1000 solution (which comes in vials) is given SC; if the reaction is to a sting or an injection on an extremity, a tourniquet is placed above the injection site and 0.5 ml of a 1:1000 solution is given SC in another extremity. For severe reactions, 5 ml of a 1:10,000 solution is given slowly IV.<br>3. In mild to moderate asthmatic attacks in adults, 0.3–0.5 ml of 1:1000 epinephrine is given SC. This may be repeated at 20-min intervals, for 3 doses. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Isoproterenol (Isuprel). | Stimulates beta-adrenergic receptors causing vasodilation in heart and skeletal muscle, increased rate and force of cardiac contraction, bronchodilation and relaxation of gastro-intestinal smooth muscle. | Bronchodilation; increased rate and force of cardiac contraction; vasodilation. | Cardiac:<br>1. To restore ventricular beat in asystole.<br>2. To increase ventricular rate in heart block.<br>3. Hypovolemic, septic or neurogenic shock that do not respond to blood volume replacement.<br>Lung:<br>1. Bronchospasm due to asthma.<br>2. Emphysema.<br>3. Chronic bronchitis. | 1. Angina pectoris.<br>2. Hypertension<br>3. Hyperthyroidism. | 1. Anxiety, tremulousness.<br>2. Palpitations. | Cardiac indications: IV drip—2 μg/ml at a rate to maintain a ventricular rate of 60/min; add 1 mg isoproterenol to 500 ml D5W to obtain a concentration of 2 μg/ml; SC—0.1–0.25 mg.<br>Pulmonary indications: 0.25 mg SC; or 10% aerosol mist for inhalation. |
| Furosemide | Decreases sodium reabsorption by the renal tubular cells, causing increased excretion of sodium and water. | Potent diuretic, causing the excretion of large volumes of urine within 5–30 min of its administration. Thus useful in ridding the body of excess fluid present in CHF. It is not used often in the field, especially if distances to hospital are short. However, may be useful in long-distance transport of patients in marked heart failure (especially catherterized patients) where a need to begin definitive therapy before the patient arrives at the hospital. | To treat congestive heart failure with associated pulmonary edema. | 1. Should not be given to pregnant women.<br>2. Should not be given to patients with hypokalemia (low potassium). This may be suspected in a patient who has been on chronic diuretic therapy or whose EKG shows prominent P waves and presence of U waves. | Immediate side effects may include nausea and vomiting, potassium depletion, and dehydration. | 40–80 mg (2–4 ml) slowly IV<br>Oral and IM routes not recommended in the field. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Diazepam (Valium). | Depresses reticular activating system (RAS) in brain, thus decreasing the level of consciousness. In addition, exerts anticonvulsant action through an undetermined mechanism. | Through its action on the central nervous system, can terminate some seizures and also exert a calming effect on anxious patients. | 1. To treat status epilepticus.<br>2. In selected circumstances, to relieve severe tension and anxiety. | 1. Should not be given to pregnant women because of possible harm to fetus.<br>2. Should not be given to patients who have ingested other sedatives or alcohol.<br>3. Should not be given to patients with respiratory depression from any source.<br>4. Should not be given to patients with hypotension. | 1. Possible hypotension.<br>2. Confusion; stupor.<br>3. In some patients—especially the elderly, the very ill, and those with pulmonary disease—may cause respiratory and/or cardiac arrest. | For status epilepticus, diazepam is given IV only and should be given through a large vein. Give cautiously in doses up to 10 mg IV. Before administering, record patient's BP. Then draw up 10 mg (2 ml) in a syringe. Give 0.5 ml slowly IV. Wait a few minutes and recheck BP. If it has fallen, do not give any more of the drug. If it is stable and the desired therapeutic effect has not been achieved, give another 0.5 ml and recheck BP. Continue until therapeutic effect has been achieved or 10 mg have been given. For AMI, give 5–10 mg IV at a rate of 5 mg/min. Dose may be repeated in 1–4 hrs. |
| 50% Dextrose (D5W, 50% glucose). | Increases serum glucose level. | Restores circulating blood sugar level toward normal in hypoglycemia. | 1. To treat coma caused by hypoglycemia.<br>2. To treat coma of unknown origin.<br>3. To treat status epilepticus of uncertain etiology; used in conjunction with other medications. | None ...................... | None ...................... | 50 % dextrose is supplied in 50 ml syringes containing 25 g.<br>The entire contents of the 50 ml syringe are given by IV bolus. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Activated Charcoal USP. | Absorbs ingested poison. | Absorbs many poisonous compounds, thus reducing their absorption by the body. Particularly effective in binding aspirin, amphetamine, strychnine, dilantin, and phenobarbitol. | To treat certain cases of poisoning and overdose after the stomach has been emptied. | 1. Should not be given before or together with syrup of Ipecac because it will absorb the Ipecac and render it ineffective.<br>2. Of no value in poisoning due to methanol. Should not be used.<br>3. Cyanide poisoning.<br>4. Should not be used if not stored in tightly sealed container. | None ...................... | 2 or more tablespoons mixed with tap water to make a slurry; given by mouth |
| Oxytocin (Pitocin). | Acts directly on uterine muscle to produce contraction; also acts directly on mammary glands causing milk ejection. | Promotes contraction of uterus toward its normal size and thereby reduces postpartum hemorrhage. | To reduce bleeding and promote contraction of the uterus after delivery of the placenta. | In the field, oxytocin should not be used until after the baby has been fully delivered. | Hypertension.......... | Given by IV infusion, prepared by injecting 10 units of oxytocin into a liter of D5W or saline |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Dopamine (Intropin). | At therapeutic doses acts on specific dopamine *receptors* to produce vasodilation in the heart, brain, kidneys, and intestines. Through vasodilation in the kidneys, dopamine increases urine output and sodium excretion. At therapeutic doses, also increases force of cardiac contraction without increasing heart rate through action on beta-adrenergic receptors. At high doses, causes predominately vasoconstriction through alpha-adrenergic receptors. | Beta-adrenergic effects at low doses; alpha effects at high doses. | To treat certain cases of cardiogenic and neurogenic shock. | Hypotension resulting from hypovolemia as in severe hemorrhage. | In pressor doses, similar to norepinephrine, although local skin necrosis is less of a problem. | By titrated infusion, 1 ampule in 250 ml D5W, to run at 6–16 μg/kg/min depending on orders from physician. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Atropine | Attaches to acetylcholine receptor on effector organ to block effect of acetylcholine release from postganglionic parasympathetic neuron; has little effect on transmission of impulses by acetylcholine in autonomic ganglia. | By blocking parasympathetic (vagal) action on the heart, atropine enhances conduction through the atrioventricular (AV) junction and accelerates the heart rate. In addition, by speeding up the heart towards a normal rate, it reduces the chances of ectopic activity in the ventricle and of ventricular fibrillation. Atropine is the most effective in reversing bradycardias caused by increased parasympathetic tone or by morphine; it is less effective in treating bradycardias due to actual damage to the SA or AV node. | 1. Sinus bradycardia with a pulse of less than 60 when accompanied by PVCs or systolic blood pressure less than 90 mmHg.<br>2. Second and third degree heart block when accompanied by bradycardia. | Rapid atrial flutter or atrial fibrillation. | Blurred vision, dryness of mouth, flushing of skin, urinary retention (especially in older men), headache, and pupillary dilatation. The patient should be warned that he might experience some of these feelings, and that they are an expected part of the drug's effect. | Atropine is usually supplied in a solution of 1 mg/ml and is in a dose of 0.01 mg/kg. For practical purposes, this means that the average adult should receive 0.5 mg (0.5 ml) IV push. This may be repeated at 5 min intervals, but the total dose should not exceed 2 mg. Each dose of atropine should be given rapidly, as slow administration can cause a transient decrease in heart rate. In the field, atropine is almost always given IV. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Lidocaine (Xylocaine). | Depresses automaticity in the ventricular conduction system. | Suppresses ventricular ectopic activity by decreasing the excitability of heart muscle and its conduction system. | 1. To reduce or eradicate ventricular ectopic activity, especially if PVCs are occurring: more often than 6/min; 2 or more in succession; in proximity to the T wave; or in a multifocal pattern.<br>2. To prevent ventricular ectopic activity.<br>3. To prevent recurrence of ventricular fibrillation.<br>4. To treat ventricular tachycardia. | 1. Known history of allergy to lidocaine or topical anesthetics in dentist's office.<br>2. Second or third degree heart block.<br>3. Sinus bradycardia or sinus arrest. | Depresses the force of ventricular contraction and may decrease peripheral vascular resistance leading to decrease in cardiac output and BP. May also cause numbness, drowsiness, confusion, and, rarely, seizures (especially if given in high dose to patients in CHF). | In adults, given as an IV bolus of 75 mg over 30–50 seconds, followed by a 50 mg bolus every 5 minutes until the arrhythmia is suppressed or until 225 mg have been given. A continuous infusion is started within 10 minutes of the bolus administration by adding 2 g of lidocaine to 500 ml D5W to yield a concentration of 4 mg/ml. This solution is infused at a rate of 1–4 mg/per minute. |
| Aminophylline (Aminophylline is a combination of theophylline and ethylenediamine). | Directly relaxes smooth muscle in bronchial airways and pulmonary blood vessels; directly stimulates the heart to increase heart rate, force of cardiac contraction, and formulation of ectopic impulses (impulses originating outside the sino-atrial node). | 1. Through its relaxant effect on smooth muscle, promotes bronchodilation and thus helps relieve bronchoconstruction of asthma, chronic obstructive pulmonary disease, anaphylaxis, etc..<br>2. Through its stimulant effect on the heart, increases the rate and strength of cardiac contractions, thus improving cardiac output in congestive heart failure. | 1. To treat bronchospasm in asthma, anaphylaxis, and decompensated chronic obstructive pulmonary disease.<br>2. To treat selected cases of pulmonary edema secondary to congestive heart failure. | There are no absolute contraindications to use of aminophylline. However, great caution must be used in giving this medication to patients with cardiac irritability, severe hypotension, or massive myocardial infarction. | 1. Nausea and vomiting.<br>2. Headache.<br>3. Hypotension.<br>4. Occasional serious dysrhythmias (MONITOR).<br>5. Convulsions, coma, and circulatory collapse.<br>All of the above are more likely to occur if aminophylline is given too rapidly. | Given by IV infusion. For adults, add 500 mg aminophylline to 250 ml D5W and run in over 30–60 min; in patients with severe congestive heart failure, who may not tolerate this fluid load, dilute in smaller volumes. The asthmatic, however, needs large volumes of fluid. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Hydrocortisone (Solu-Cortef, Decadron, Solu-Medrol, etc. presented as a model for corticosteroids). | Stimulates production of glucose from proteins; thought to stabilize cell membranes; thought to stabilize capillary walls to inflammatory response. | Controversial. Some physicians feel these agents diminish the severity of allergic and inflammatory reactions and perhaps improve circulation through the capillaries. | To control severe allergic states, such as anaphylaxis, acute asthma; in conjunction with epinephrine (controversial), to ameliorate some manifestations of shock; to decrease cerebral edema (controversial), Decadron or Solu-Medrol only. | None, to a single IV dose in the field. | If administered too rapidly, especially in large doses, may cause hypotension, and cardiovascular collapse; otherwise no known side effects to a single dose of corticosteroids. | For the treatment of shock and related conditions, the physician may order massive doses of hydrocortisone, in the range of 5–10 g.<br>For cerebral edema, dose of Decadron is 10 mg IV and the dose of Solu-Medrol is 50 mg IV. |
| Meperidine (Demerol). | Depresses sensory area of cerebral cortex—painful stimuli continue to be received by the cerebral cortex but are no longer interpreted as painful. | Relieves pain, produces less contraction of smooth muscle in the biliary tract than morphine (Demerol is thought to be bettern than morphine for relief of pain due to obstruction in the biliary system). | To treat pain. | 1. Marked hypotension.<br>2. Respiratory depression.<br>3. Asthma, chronic obstructive lung disease.<br>4. Should not be used in patients who have taken other depressant drugs, such as alcohol and barbiturates.<br>5. Should not be used to treat chronic pain except with the terminally ill, as meperidine is addictive. | 1. Hypotension.......<br>2. Respiratory depression.<br>3. Bradycardia due to increased vagal tone.<br>4. Nausea and vomiting.<br>5. Constipation.<br>6. Urinary retention.<br>7. Addiction. | 80–100 mg is equivalent in effect to 10 mg morphine. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Deslanoside (Cedilanid). | Increases force and efficiency of cardiac contraction; slows conduction through AV node, increases AV node refractory period; decreases SA node firing rate. | Relieves congestive heart failure by increasing force and efficiency of cardiac contraction; increased cardiac output produces diuresis, decreased venous pressure, lowered heart rate, decreased heart size. | 1. Congestive heart failure.<br>2. Atrial fibrillation.<br>3. Atrial flutter<br>4. Supraventricular tachycardia. | 1. Ventricular tachycardia due to digitalis.<br>2. Infectious myocarditis, acute pulmonary, cardiogenic shock.<br>3. Calcium administration.<br>4. Potassium depletion. | 1. Loss of appetite, nausea, vomiting, diarrhea.<br>2. EKG changes: sinus bradycardia, P-R prolongation, AV dissociation, ventricular arrhythmias, atrial arrhythmias with some AV block.<br>3. Visual disturbances.<br>4. Drowsiness, headache, confusion, toxic psychosis. | 1.2–1.8 mg IV, as initial dose. |

# APPENDIX B

## OTHER SIGNIFICANT DRUGS

The following drugs, for the most part, are not used in the field, but are frequently taken by patients at home. The paramedic should be aware of the conditions for which the drugs are taken and some of the effects these drugs have. In many cases, the medications that the patient takes at home influence what medications can safely be administered under emergency conditions. The patient taking digitalis, for example, should not receive calcium preparations unless they are urgently needed—and then only in reduced dosage. The patient taking diuretics may be potassium depleted and, therefore, particularly sensitive to bicarbonate, which can further lower serum potassium.

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Digitalis (Digoxin, Digitoxin). | Increases force and efficiency of cardiac contraction; slows conduction through AV node refractory period; increases formation of ectopic impulses; decreases SA node firing rate. | Relieves congestive heart failure by increasing force and efficiency of cardiac contraction; increased cardiac output produces diuresis, decreased venous pressure, lowered heart rate, decreased heart size. | 1. Congestive heart failure.<br>2. Atrial fibrillation.<br>3. Atrial flutter<br>4. Supraventricular tachycardia. | 1. Ventricular tachycardia due to digitalis.<br>2. Infectious myocarditis, acute pulmonary edema, cardiogenic shock.<br>3. Calcium administration.<br>4. Potassium depletion. | 1. Loss of apetite, nausea, vomiting, diarrhea.<br>2. EKG changes—P-R prolongation, AV dissociation, sinus bradycardia, ventricular arrhythmias with some AV block.<br>3. Visual disturbances.<br>4. Drowsiness, headache, confusion, toxic psychosis. | Daily maintenance doses: Digitoxin, .05–0.3 mg; Digoxin, 0.25–0.75 mg. |
| Nitroglycerin ......... | 1. Lowers central venous pressure.<br>2. Reduces the work of the heart by dilating systemic arteries. | Relieves pain of angina pectoris. | Angina pectoris...... | Virtually none........ | Systemic vasodilation causes:<br>1 Throbbing headache.<br>2. Increased intraocular pressure.<br>3. Decreased blood pressure. | 0.4–0.6 mg tablet sublingually at onset of angina pectoris; effect lasts about 5 min. |
| Propranolol (Inderal). | Blocks beta-adrenergic effects; this leads to bradycardia, decreased atrial and ventricular contractility, and decreased AV conduction rate; bronchodilation is also blocked; also has non-beta-related effects: suppresses ectopic pacemakers and slows conduction within the ventricles. | 1. Decreases rate of sinus node or ectopic atrial pacemaker during arrhythmia.<br>2. By slowing AV conduction, decreases ventricular response rate to rapid supraventricular rhythm.<br>3. Supresses ectopic foci, especially in the ventricles.<br>4. Prevention of anginal pectoris attacks.<br>5. Lowers blood pressure. | 1. Sinus tachycardia.<br>2. Idiopathic hypertrophic subaortic stenosis with increased sympathetic outflow.<br>3. Digitalis-induced atrial tachycardia, ventricular tachycardia, or ventricular ectopic beats.<br>4. Prevention of angina pectoris attacks.<br>5. Hypertension. | 1. Congestive heart failure.<br>2. Hypotension unless associated with arrhythmia.<br>3. Cardiogenic shock.<br>4. Complete heart block.<br>5. Asthma or chronic obstructive lung disease.<br>6. Insulin-dependent diabetes mellitus. | 1. Heart failure may develop when administered to patients with serious arrhythmias.<br>2. Hypotension.......<br>3. Av block<br>4. Bronchoconstriction. | 10–40 mg orally 3–4 times daily or 1 mg IV at 1 mg/min while monitoring EKG. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Diuretics<br>Chlorthiazide (Diuril).<br>Hydrochlorothiazide (Hydro-DIURIL, Esidrex).<br>Furosemide (Lasix).<br>Ethacrynic Acid (Edecrin).<br>Trichlormethiazide (Naqua). | Decreases renal tubular reabsorption of sodium (furosemide and ethacrynic acid are more potent than the thiazides: chlorthiazide, hydrochlorothiazide. | By decreasing renal tubular reabsorption of sodium, increases excretion of sodium and water, thus decreasing extracellular fluid volume. This decreases edema and lowers blood pressure. | 1. Hypertension<br>2. Edema. | 1. May produce digitalis toxicity if given in addition to digitalis.<br>2. May worsen diabetes mellitus. | 1. Potassium depletion—this may produce toxicity in patients taking digitalis.<br>2. Impaired glucose tollerance.<br>3. Weakness, paresthesis.<br>4. Nausea and abdominal cramping with ethacrynic acid. | Chlorthiazide: 0.5–1 g orally daily.<br>Hydrochlorothiazide: 25–100 mg daily.<br>Trichlormethiazide: 2.8 mg orally daily.<br>Furosemide: 40–80 mg orally daily.<br>Ethacrynic acid: 20–150 mg orally daily. |
| Antihypertensives<br>Guanethidine (Ismelin).<br>Reserpine<br>Hydralazine (Apresoline).<br>Methyldopa (Aldomet). | Decreased sympathetic activity by a variety of more specific mechanisms. | Lower blood pressure. | Essential hypertension (elevated blood pressure). | Reserpine: psychiatric depression, congestive heart failure unless administered with a diuretic.<br>Guanethidine and Methyldopa: congestive heart failure unless administered with a diuretic. | Reserpine: bradycardia and miosis, increased gastric acid secretion, psychiatric depression.<br>Guanethidine: bradycardia, increased gastrointestinal motility, muscle weakness or tremor.<br>Hydralazine: headache, nausea, weakness, tachycardia, angina pectoris attacks, neuropathy (reversible by pyridoxine, a B-vitamin).<br>Methyldopa: bradycardia, diarrhea, faintness, weakness. | Reserpine: 0.25 mg/day orally or less.<br>Guanethidine: Initially, 10 mg/day orally, increase at weekly intervals.<br>Hydralazine: 25–100 mg/day orally.<br>Methyldopa: 250–500 mg twice daily orally. |
| Diphenylhydantoin (Dilantin). | Prevents spread of abnormal electrical activity in the brain. | Anticonvulsant action; quinindine-like effects on the heart. | 1. Grand mal epilepsy.<br>2. Psychomotor epilepsy.<br>3. Convulsions not caused by epilepsy. | Liver disease | 1. Muscular incoordination, slurred speech.<br>2. Hypertrophy of the gums.<br>3. Folic acid deficiency.<br>4. May intensify petit mal attacks in mixed epilepsy. | 100-300 mg 1–2 times daily. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Insulin | Replaces insulin, which is deficient in patients with mellitus; insulin increases cellular uptake of glucose, amino acids, potassium, and phosphate. | Lowers blood glucose by increasing glucose uptake by muscle and fat tissue and by decreasing release of glucose from the liver; also decreases fat breakdown and subsequent formation of ketones, which produce ketoacidosis. | Diabetes mellitus | None for the treatment of diabetes mellitus with insulin. | 1. Overdose toxicity due to changes in insulin requirements, symptoms begin with hunger, weakness, tachycardia, numbness, tingling and tremor and progress to convulsions, coma and death; insulin overdose is treated by glucose administration.<br>2. Allergic reactions. | Dosages vary with the severity of the insulin deficiency. Insulin is available in short-acting forms such as Crystalline zinc, insulin, or semilente; intermediate acting forms: NPH or Lente; and long-acting forms: protamine zinc insulin, or Ultralente. |
| Oral hypoglycemic agents.<br>Tolbutamide (Orinase).<br>Chlorpropamide (Diabinese).<br>Acetohexamide (Dymelor).<br>Tolazamide (Tolinase). | Stimulation of insulin release from the pancreas. | Decrease blood glucose levels through increased levels of insulin (do not effectively lower blood glucose levels in patients requiring more than 25–35 units insulin daily). | Maturity-onset diabetes mellitus that requires less than 25–35 units insulin daily. | 1. Diabetic ketoacidosis.<br>2. Diabetic coma.<br>3. Renal and hepatic disease. | Increased gastric secretion causing nausea, abdominal pain, and diarrhea; profound hypoglycemia diabetic acidosis. | Tolbutamide: 0.5–3g daily orally in divided doses.<br>Chlorpropamide: 0.1–0.5 g orally daily.<br>Acetohexamide: 0.25–.15 g orally daily.<br>Tolazamide: 0. 1–0.5 g orally daily. |
| Methadone | Depresses sensory area of cerebral cortex; painful stimuli continue to be received by the cerebral cortex but are no longer perceived as painful. | Relieves moderate to severe pain; suppresses symptoms of withdrawal from narcotics, including heroin and morphine; is used as oral substitute drug for maintenance of heroin and morphine addicts. | 1. Moderate to severe pain.<br>2. Maintenance of heroin and morphine addicts.<br>3. Can be used in decreasing doses during withdrawal from narcotic drugs to prevent withdrawal symptoms. | 1. Marked hypotension.<br>2. Respiratory depression.<br>3. Asthma, chronic obstructive lung disease.<br>4. Should not be combined with alcohol or barbiturates.<br>5. Should not be used to treat chronic pain in nonaddicts unless the pain results from a terminal illness since methadone is addictive.<br>6. Bleeding or potential bleeding. | 1. Hypotension<br>2. Respiratory depression.<br>3. Bradycardia due to increased vagal tone—can be treated with atropine.<br>4. Nausea and vomiting.<br>5. Constipation.<br>6. Urinary retention.<br>7. Addiction | For pain: 5–15 mg orally every 3–4 h.<br>To maintain narcotic addicts: dose to which they are tolerant. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Heparin and Oral Anti-Coagulants (Dicumarol, warfarin, Coumadin). | Heparin: interferes with blood clotting; oral anticoagulants compete with Vitamin K to prevent synthesis in the liver of certain clotting factors. | Prevent formation and propagation of venous thrombi (blood clots in the veins), prevent formation of arterial thrombi at site of arterial occlusion, prevent formation of thrombi in fibrillating artria; heparin is also used as anticoagulant during renal dialysis. | 1. Prolonged bed rest which predisposes to venous thrombi.<br>2. Atrial fibrillation.<br>3. Mitral valve disease.<br>4. Acute arterial occlusion.<br>5. Venous thrombosis.<br>Note.—Heparin is indicated when an immediate effect is needed, as after venous thrombosis or arterial occlusion; oral anticoagulants are used to prevent thrombus formation or to maintain anticoagulation established with heparin. | Bleeding or potential bleeding. | Hemorrhage .......... | Heparin: for immediate effect 3000–9000 units IV every 4–6 h; for prolonged effect, 10,000–15,000 units SC below the posterior iliac crest every 12 h.<br>Dicumarol: maintenance 25–150 mg orally daily.<br>Warfarin: maintenance 5–15 mg orally daily. |

| Drug | Mechanism of Drug | Therapeutic Effects | Indications | Contraindications | Side Effects | Dosage |
|---|---|---|---|---|---|---|
| Oral bronchodilators.<br>Pseudoephedrine (Sudafed).<br>Theophylline (Quibron).<br>Tedral (combination of theophylline and ephedrine—same actions and effects as pseudoephedrine, and phenobarbital).<br>Marax (combination of theophylline, ephedrine, and hydroxyzine); Actifed (pseudoephedrine and triprolidine). | Pseudoephedrine: releases norepinephrine from sympathetic neurons and increases and prolongs the effect of epinephrine and norepinephrine already acting. | Relaxation of nonvascular smooth muscle, including bronchial smooth muscle; nasal decongestion through vasoconstriction. | 1. Bronchial asthma.<br>2. Nasal congestion.<br>1. Allergic reactions.<br>2. Insomnia | 1. Essential hypertension.<br>2. Chronic heart disease. | 1. Cardial stimulation producing tachycardia.<br>2. Hypertension......<br>3. Cardiac arrhythmias.<br>1. Oral administration—gastric irritation. | Pseudoephedrine: 30–60 mg orally<br>Ephedrine: 15–50 mg orally. |
|  | Theophylline: directly relaxes smooth muscle of blood vessels and bronchi; blocks renal tubular reabsorption of sodium; stimulates heart muscle to increase heart rate, force of cardiac contraction; and increases ectopic impulse formation. | Relaxation of bronchial smooth muscle. | Bronchial asthma... |  | 2. IV administration—cardiac arrhythmias in patients with coronary artery disease.<br>Drosiness, sedation, dry mouth, blurred vision, urinary retention, constipation at high doses, convulsions leading to coma. | Aminophylline (theophylline and ethylene diamine): 200 mg orally. |
|  | Hydroxyzine and Triprolidine: block effects of histamine (histamine effects include increased capillary permeability, laryngeal edema and bronchiolar constriction), cause sedation through an unknown mechanism, and have additional atropine-like and quinidine-like effects. | Prevent allergic reactions; cause sedation. | Coronary artery disease. | Patient should not drive or operate machinery while taking these antihistamines. |  | Hydroxyzine: 75–100 mg orally daily in 3–4 divided doses.<br>Triprolidine: 2.5 mg orally. |

## Module V.
# Respiratory System

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American Heart Association CPR ECC Critical Performance Rationale: Obstructed Airway

# Module V.
# Respiratory System

## Unit 1. Anatomy and Physiology of the Respiratory System

The respiratory system comprises the air passages and the lungs—the structures involved in the exchange of gases between the body and the environment. The system's function is to oxygenate the blood and to remove carbon dioxide ($CO_2$) from the body.

### Upper Respiratory Tract

On the lateral wall of each of the two inner nasal cavities are three bones: the superior, middle, and inferior turbinates. The turbinates divide the air coming in from each nostril into three horizontal streams. From the nose, air passes into the pharynx, which is divided into three sections: the nasopharynx, behind the nose; the oropharynx, behind the mouth; and the laryngopharynx, behind the laryngeal opening. (See Figure 5.1.)

From the pharynx, air passes into the larynx, a tubular structure lying anterior to the esophagus—the passageway for food between the mouth and the stomach. Within its walls, the larynx has nine cartilages, which prevent it from collapsing during inspiration. The main laryngeal cartilage, the thyroid cartilage, is a V-shaped protuberance, known as the Adam's apple, which forms the anterior wall of the larynx. Below the thyroid cartilage are the two arytenoid cartilages, which are attached to the vocal cords. The arytenoid cartilages can be seen during intubation.

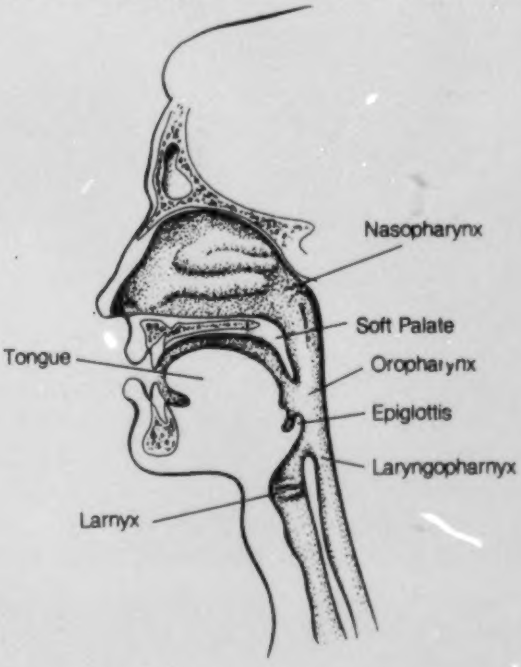


**Figure 1. Cross-Section of the Pharnyx**

Below the arytenoid cartilages is the cricoid cartilage, which forms the lowest part of the larynx.

The vocal cords lie within the larynx. They regulate air passage through the larynx and control sound production. For this reason, the larynx is also called the voice box. The epiglottis, a cartilaginous flap, closes over the laryngeal opening during swallowing to help prevent aspiration of food.

Most of the larynx is lined with ciliated epithelia that secrete mucus—a thick, sticky fluid that traps foreign particles. The cilia, hairlike projections on the epithelial-cell surfaces, move the foreign particles contained in the mucus upward toward the pharynx to help clean the airways.

## Lower Respiratory Tract

Air passes from the larynx into the trachea, a tubular structure 4 to 5 inches long that extends from the seventh cervical vertebra (C7) to about the fourth or fifth thoracic vertebra (T4 or T5). Cartilage present in the wall of the trachea also prevents its collapse during inspiration. Like the larynx, the trachea is lined with ciliated mucus-secreting epithelia to help clean the airways.

The trachea ends at about T4 or T5, where it divides into the right and left mainstem bronchi. The point of bifurcation (division) is called the carina. Like the larynx and trachea, the bronchi have cartilaginous walls and are lined with ciliated, mucus-secreting epithelia. The right mainstem bronchus is shorter and straighter than the left. Therefore, foreign bodies and endotracheal tubes inserted too far into this cavity tend to enter the right mainstem bronchus, rather than the left.

Each bronchus enters its respective lung accompanied by a pulmonary artery and two pulmonary veins. The bronchi, arteries, and veins branch into three divisions on the right and two divisions on the left, thereby supplying the three lobes of the right lung and the two lobes of the left lung.

In addition to pulmonary arteries and veins, the lungs are also supplied by bronchial blood vessels. The bronchial arteries originate in the thoracic aorta and supply the walls of the air passages within the lungs as far as the respiratory bronchioles. Blood from the bronchial arteries passes through capillary beds and then empties into either pulmonary or bronchial veins.

The bronchi, supplying individual lung lobes, divide again to form segmental bronchi, which supply bronchopulmonary segments. (see Figure 5.2.) The segmental bronchi divide into smaller and smaller bronchi, finally forming bronchioles, and then respiratory bronchioles. Respiratory bronchioles have no cartilage in their walls.

The respiratory bronchioles divide into alveolar ducts. These ducts lead to the alveolar sacs, which envelop the alveoli. Alveoli contain thin epithelial linings and dense capillary networks and are responsible for oxygen and carbon dioxide exchange between alveolar air and pulmonary capillary blood.

In extremely simple terms, the lungs are two conical organs whose bases rest on the diaphragm, a convex skeletal muscle. The lungs are enclosed by a membrane called the visceral pleura, which lies against the parietal pleura, the membrane lining the thoracic cavity. The space between the two membranes, the pleural space, is a potential rather than an actual space, because the visceral and parietal layers are in contact. A thin layer of fluid in the pleural space lubricates the pleura and allows the lungs to move freely in the thoracic cavity. But if air or fluid enters the pleural cavity, which sometimes occurs in chest trauma, the potential space becomes actual space.

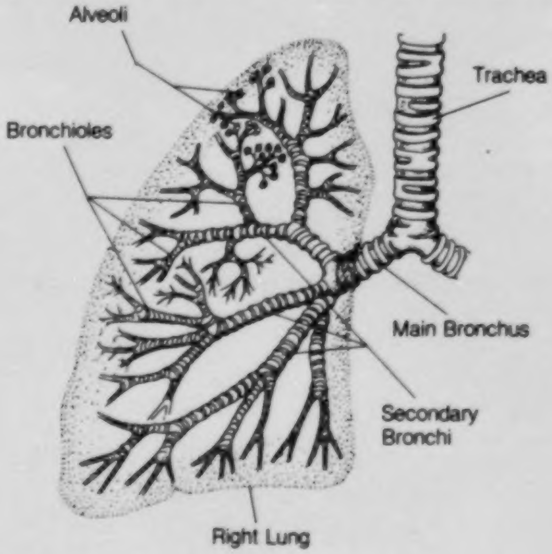


**Figure 2. Segmental Bronchi**

The lungs lie in a position superior to the diaphragm, within the cavity formed by the ribs, and are separated by the mediastinum. The apex, or top, of each lung rises about 2.5 centimeters (cm) above the medial third of the clavicle.

Breathing occurs as a result of pressure changes in the lungs, which result from respiratory muscle contraction and relaxation. Quiet inspiration begins by contraction of the diaphragm and the intercostal muscles. When the diaphragm contracts, it pulls its central tendon downward, increasing the vertical dimensions of the thoracic cavity. The intercostal muscles originate on the lower border of each rib and insert on the upper border of the rib beneath it. When these muscles contract, they elevate the ribs and move them outward, thus increasing the horizontal dimensions of the thoracic cavity.

The combined contraction of the diaphragm and the intercostal muscles increases thoracic volume and decreases intrathoracic pressure. Air flows in because the pressure in the airways is less than atmospheric pressure. Quiet expiration occurs when the inspiratory muscles relax, decreasing thoracic volume and increasing intrathoracic pressure. This situation will force air out of the lungs, raising the alveolar pressure higher than the atmospheric pressure.

When air exchange produced by contraction and relaxation of the diaphragm and intercostal muscles is inadequate, as in respiratory distress, accessory muscles aid inspiration and expiration. The abdominal wall muscles are used to aid expiration when there is increased resistance to airflow out of the lungs. Contraction of these muscles raises the diaphragm, thus decreasing thoracic volume and increasing intrathoracic pressure. The muscles of the neck also aid inspiration when called on.

## Measures of Respiratory Function

In the normal adult, the respiratory rate during quiet breathing is about 14 to 18 inspirations per minute. Inspiration occupies about one-third of the time of the respiratory cycle; expiration occupies about two-thirds. In infants, the normal respiratory rate is 40 to 60 respirations per minute; in children, about 24 per minute. Such factors as fever, anxiety, and insufficient oxygen increase the respiratory rate. Depressant drugs and sleep decrease the respiratory rate.

The total lung capacity is the volume of gas contained in the lungs at the end of a maximal inspiration. For an adult male, lung capacity is about 6 liters (l). But, only a small part of the total lung capacity is used during each respiratory cycle. A normal tidal volume—the volume of gas inhaled or exhaled during a single respiratory cycle—is about 500 milliliters (ml). Of this amount, about 150 ml remains in the air passageways, unavailable for gas exchange. This volume is called dead-space air. The remaining 350 ml, which reaches the alveoli and exchanges oxygen and carbon dioxide with the capillary blood, is called alveolar air.

Minute volume, the amount of gas moved in and out of the respiratory tract per minute, is a useful measure of respiratory function. It is determined by:

- The volume of each breath (tidal volume).
- The number of breaths per minute (respiratory rate).

Therefore:

a normal minute volume = (normal tidal volume) × (normal respiratory rate)

= (500 ml per breath) × (14 breaths per minute)

= 7,000 ml (or 7 l)

Minute volume increases if either tidal volume or respiratory rate increases and, conversely, decreases if either tidal volume or respiratory rate decreases.

## Exchange of Gases in the Lung

The alveoli supply oxygen ($O_2$) to and remove carbon dioxide ($CO_2$) from the pulmonary capillary blood. The blood coming from the tissues to the alveoli is low in $O_2$ because the tissues consume $O_2$ during metabolism. Alveolar air, in contrast, is higher in $O_2$ and contains little $CO_2$. Essentially, the alveoli allow the blood to trade its stale air for a fresh supply. The process is shown in Figure 5.3.

The $O_2$ and $CO_2$ content in the alveoli and capillaries are measurable in terms of their partial pressures. Partial pressure represents the pressure that a gas would exert were it the only gas present in a given space. The sum of the partial pressures of all gases present in a mixture yields the total gas pressure. Therefore, the partial pressure of any individual gas in a mixture equals the fractional concentration of that gas multiplied by the total pressure of the gas mixture. Fractional concentration is the percentage divided by 100. Total gas pressure at sea level equals atmospheric pressure or 760 millimeters of mercury (mm Hg). An alternate measure of gas pressure is the torr, which equals 1 mm Hg. The pressure exerted by 1 mm Hg or 1 torr equals the pressure exerted by a water column 1.36 cm high.

Room air contains approximately 21 percent $O_2$ and very little $CO_2$. Breathing room air produces an alveolar partial pressure of oxygen ($PO_2$) of about 140 torr, and an alveolar partial pressure of carbon dioxide ($PCO_2$) close to zero. Venous blood coming to the alveoli from the tissues has a $PO_2$ of about 40 torr and a $PCO_2$ of about 46 torr.

Gas diffuses from areas of higher partial pressure to areas of lower partial pressure. Therefore, $O_2$ will diffuse from the alveolar air into the pulmonary capillaries. In contrast, $CO_2$ will diffuse from the pulmonary capillaries into the alveolar spaces.

The rate of gas diffusion across pulmonary membranes depends on their solubility in water, which is the membranes' main component. $CO_2$ is 21 times more soluble in water than $O_2$ is. For this reason, changes in pulmonary membrane thickness have less effect on $CO_2$ than on $O_2$ diffusion.

Oxygen diffuses into the blood plasma and combines with hemoglobin. When hemoglobin is saturated (completely combined with $O_2$), each gram (g) carries 1.34 ml of $O_2$. At a normal hemoglobin level of 15 g/100 ml, 20 ml $O_2$ may be carried per milliliter of blood. When the hemoglobin level falls, the blood can carry less $O_2$ per milliliter.

Hemoglobin remains close to being fully saturated with oxygen at $PO_2$ of 50 to 100 mm Hg. The normal arterial $PO_2$ ranges from 80 to 100 mm Hg; therefore, arterial hemoglobin is normally almost fully saturated with oxygen.

At $PO_2$'s below 50 torr, small $PO_2$ decreases produce large decreases in hemoglobin saturation. This aids O2

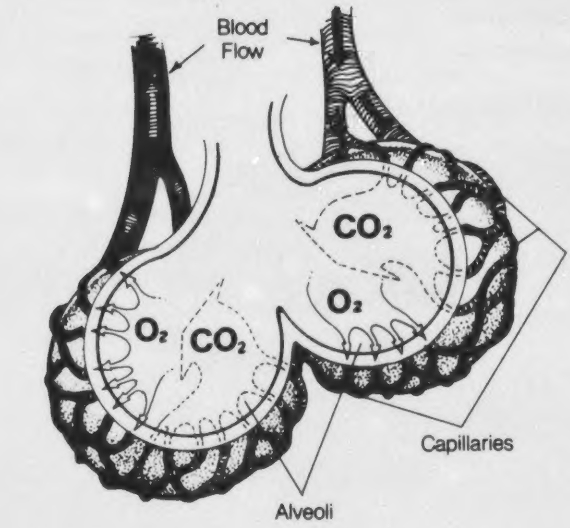


**Figure 3. $CO_2/O_2$ Exchange in the Aveoli**

delivery to the tissues, which have low $PO_2$ levels. Hemoglobin saturation is additionally decreased at a given $PO_2$ level by high $PCO_2$ and decreased pH. (Below normal arterial pH is 7.35 to 7.45.) This also aids $O_2$ delivery to the tissues, which have increased $PCO_2$ levels and decreased pH.

Carbon dioxide from the tissues is carried in the blood in three forms: About 66 percent is transported as bicarbonate; about 33 percent combines with hemoglobin; and a small amount dissolves in the plasma. After exchange with alveolar gases, the blood returning to the left heart (the arterial blood) normally has a $PO_2$ of 80 to 100 torr and a $PCO_2$ of 35 to 40 torr.

In summary, $O_2$ is diffused continuously from the alveoli into the pulmonary capillary blood, and $CO_2$ is diffused from the pulmonary capillary blood into the alveoli. During inspiration, $O_2$ that has been absorbed from the alveoli is replaced; during expiration, $CO_2$ that has accumulated in the alveoli is washed out.

## Regulation of Respiration

Although respiration can be controlled voluntarily (talking, sighing, holding of breath, etc.), respiratory action is mainly involuntary. Respiratory rate and depth are controlled by a respiratory center located in the brainstem.

The respiratory center mediates the Hering-Breuer reflex, which regulates respiratory rhythm. During inspiration, the lungs stretch, stimulating the stretch receptors that are located within them. The receptors send inhibitory messages through the vagus nerves to the inspiratory area in the respiratory center. As the lungs continue to stretch, more and more inhibitory messages are sent to the inspiratory center until, finally, the inspiratory center shuts down, allowing expiration. As expiration proceeds, fewer and fewer inhibitory impulses reach the medullary inspiratory center. The inspiratory center, now no longer inhibited, signals the inspiratory muscles to contract again, beginning inspiration.

Respiration is also carefully regulated to maintain $PO_2$, $PCO_2$, and pH within narrow limits. Central chemoreceptors are located in the medulla; peripheral chemoreceptors are located in the aortic arch and carotid bodies (located at the division of the common carotid arteries into the internal and external carotid arteries). These chemoreceptors are stimulated by increased $PO_2$, decreased $PCO_2$, or decreased pH. Normal values for these are: arterial $PCO_2$, 40 torr; arterial $PO_2$, 80 to 100 torr; and arterial pH, 7.35 to 7.45.

The respiratory center responds to arterial $PCO_2$ levels above 40 mm Hg by increasing the rate and depth of respiration. The medullary respiratory center, similarly, increases rate and depth of respiration in response to decrease arterial $PO_2$. Arterial $PO_2$ must fall below 60 mm Hg, however, before respiration is stimulated. Therefore, $PO_2$ is less finely controlled than is $PCO_2$.

Normally, fluctuations in $PCO_2$ and pH are the dominant influences on respiration, and the respiratory drive arises from the body's attempt to regulate arterial $PCO_2$. Some individuals have chronic respiratory disease, however, and are unable to eliminate $CO_2$ normally. Their respiratory centers, therefore, become accommodated to high $PCO_2$ levels. What then, stimulates these individuals to breathe? Here, respiratory rate and depth respond to arterial $PO_2$ levels below 60 torr. Patients whose dominant control of respiration comes from changes in $PO_2$ are said to operate on hypoxic drive.

## Modified Forms of Respiration

Coughing is the forceful exhalation of a large volume of air. During coughing, the abdominal muscles contract forcefully against a closed glottis, producing increased intrathoracic pressure. As the vocal cords open partially, a gust of air is propelled past them with great force, dislodging foreign particles from the air passages and expelling them. Coughing, therefore, serves a protective function. For this reason, the patient whose cough reflex is suppressed by drugs, pain, or trauma may aspirate foreign material.

Sneezing is also a sudden, forceful exhalation; but in this case, air is expelled from the nose rather than the mouth. Sneezing is usually caused by nasal irritation. Hiccuping is a sudden inspiration, caused by a spasmodic contraction of the diaphragm cut short by closure of the glottis. Hiccuping serves no useful purpose and is usually harmless and self-limited, but may sometimes occur as a symptom of a serious illness.

Sighing is a slow, deep inspiration followed by a prolonged, and sometimes audible expiration. Sighing periodically hyperinflates the lungs, thus reexpanding atelectatic areas.

### Factors Altering Carbon Dioxide Levels in the Blood

Arterial $PCO_2$ represents a balance between $CO_2$ produced during metabolism and $CO_2$ eliminated through respiration. When the two volumes balance, arterial $PCO_2$ is about 40 torr. This equilibrium can be seen in Figure 5.4.

If $CO_2$ production exceeds $CO_2$ elimination, $PCO_2$ rises. This condition can occur through (1) increased $CO_2$ production (e.g., fever, muscular exertion, and shivering) or (2) decreased $CO_2$ elimination (e.g., respiration suppressed by drugs and airway obstruction).

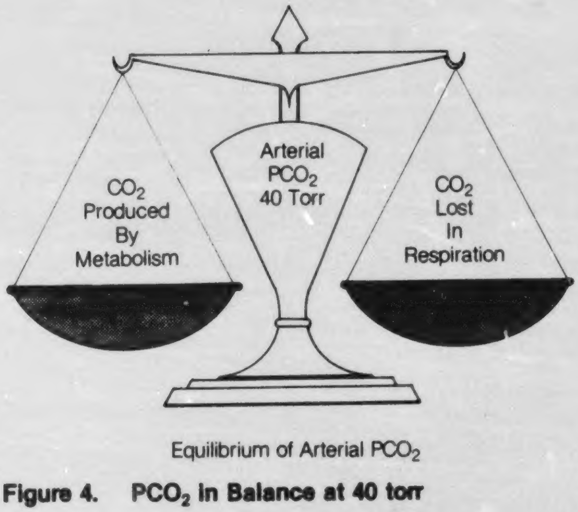
When $CO_2$ elimination exceeds $CO_2$ production, the arterial $PCO_2$ falls. This occurs during hyperventilation. The amount of $CO_2$ removed from the blood depends on the volume of air exchanged per minute (minute ventilation). The greater the minute volume, the greater the amount of $CO_2$ eliminated from the blood. Hence, given a constant rate of $CO_2$ production:

hyperventilation→ ↑ $CO_2$ elimination→ ↓ arterial $PCO_2$ (hypocarbia)

hypoventilation→ ↑ $CO_2$ elimination→ ↑ Arterial $PCO_2$ (hypercarbia)

### Factors Altering Oxygen Levels in the Blood

In the normal alveolus/capillary unit, blood is fully oxygenated when it passes through the alveolus. But in some cases, blood may not become fully oxygenated in its passage through the alveoli. For example, fluid may occupy the alveolar interstitial spaces and alveolar air spaces, producing pulmonary edema. This situation occurs in left heart failure, drowning, and toxic inhalations. Excessive alveolar fluid increases the distance which $O_2$ and $CO_2$ must diffuse across the alveolar air spaces and the pulmonary capillaries. The $O_2$ is less soluble in water than the $CO_2$. Therefore, it diffuses less easily across the increased distance, and hypoxemia results.



Equilibrium of Arterial $PCO_2$

**Figure 4. $PCO_2$ in Balance at 40 torr**

Alveoli may also collapse, producing atelectasis (collapsed lung). External causes—a pneumothorax from perforation of the chest wall, for example—can provoke this condition but so can such internal causes as secretions plugging the airways or poor coughing and sighing. When this happens, blood flowing past nonfunctional alveoli does not pick up $O_2$, and the arterial blood is not fully oxygenated. As a result, the $PO_2$ falls. This situation is called "shunting" because part of the blood from the right heart never picks up $O_2$ (as if it had been shunted past the lungs).

One partial remedy to this problem is to give the atelectasis patient supplemental oxygen, thus supplying a higher $O_2$ concentration to the alveoli still functioning. Intermittent positive-pressure ventilation (IPPV), using a demand valve, can be used to increase the patient's oxygen supply; IPPV can be defined as mechanical assistance to ventilation by the intermittent application of positive pressure to the patient's airway either at a preset rate or when triggered by the patient's inspiratory effort. In pulmonary edema, IPPV creates a force that helps drive fluid out of the alveoli, therefore, improving gas exchange. The application of IPPV may, similarly, improve gas exchange in atelectasis by forcing open collapsed alveoli.

## Unit 2. Patient Assessment

Strictly speaking, acute respiratory insufficiency exists when the arterial $PCO_2$ rises above 50 torr and the arterial $PO_2$ falls below 60 torr. Measurements of arterial blood gases, however, cannot be made in the field. Therefore, you must learn to assess the patient's respiratory status by clinical observation.

### History: The Patient's Symptoms

Much can be learned from a few well-chosen questions. In taking a history from a patient with respiratory problems, you need to explore the patient's chief complaint in greater depth. In most cases, this complaint will be dyspnea (difficulty in breathing). But some patients may have serious respiratory problems without dyspnea, especially if their respiration has been depressed by drugs or trauma. Therefore, you must be alert for respiratory problems, even if the patient does not complain of shortness of breath. Assuming that the chief complaint, however, is dyspnea, obtain answers to these questions:

- How long has the dyspnea been present? Is the problem longstanding, as in the patient with chronic obstructive pulmonary disease, or of recent onset, as in pneumothorax?

- Was the onset gradual or abrupt? The dyspnea associated with asthma or congestive heart failure may develop gradually, over several hours, while that associated with pulmonary embolism or pneumothorax may come on with striking suddenness.
- Is the dyspnea made better or worse by any position? Dyspnea that is more acute when the patient is lying down (orthopnea) is often related to congestive heart failure, because the horizontal position fosters the pooling of blood in the lungs. But most patients with dyspnea from respiratory problems feel more comfortable in a sitting position.
- Has the patient been coughing? If so, is the cough productive? What does the sputum look like? Patients with chronic obstructive pulmonary disease often have a chronic cough associated with thick white sputum. When such patients decompensate, their sputum changes in volume and character and may become purulent (yellow-green and thick). Purulent sputum is also associated with pneumonia. The patient with pulmonary edema often produces foamy, blood-tinged sputum. Coughing up frank blood may be associated with heart disease, tuberculosis, and trauma to the respiratory tract.
- Is there associated pain? If so, what is its nature? Abrupt dyspnea occurring with sudden, sharp pain may indicate a spontaneous pneumothorax or pulmonary embolism. Dyspnea occurring with heavy, squeezing substernal chest pain suggests heart failure caused by myocardial infarction.
- Has the patient suffered any medical problems in the past? The patient in congestive heart failure may have a long history of cardiac problems or hypertensive disease. For example, the asthmatic often will have had previous attacks. The patient with chronic obstructive pulmonary disease will often give a history of chronic cough and heavy smoking.
- What medications does the patient take regularly? "Breathing pills" and inhalants suggest obstructive airway disease; digitalis indicates that the patient is being treated for an underlying cardiac problem. The patient taking "blood thinners" (anticoagulants, like Coumadin) may have had a previous episode of pulmonary embolism.

From the answers to these questions, you can form a general idea of what is happening to the patient. The physical examination will allow you to check hypotheses and gain further information.

## Physical Examination: The Patient's Signs

A large amount of valuable information concerning the patient's condition can be gathered through observations made during history taking. When taking a history from a patient with a respiratory problem, you must answer these questions:

- Is the patient anxious, uncomfortable, or in distress?
- Does dyspnea make it difficult for the patient to speak? Does the patient need to stop to catch his or her breath when answering questions?
- Does questioning easily distract the patient from symptoms?
- Are answers to your questions coherent and appropriate, or does the patient answer in a confused and disoriented fashion?
- What postural position does the patient naturally assume?

In making such observations, you are performing the first step of the physical examination—the assessment of the patient's general appearance and mental status. Thus, you can note, for example, that the patient in severe respiratory distress is frightened and intensely uncomfortable, is usually sitting upright, is gasping or laboring to breathe, and is confused or disoriented—if blood gas abnormalities are severe.

After completing the primary survey, take the patient's vital signs. Respirations should be carefully observed. Are the patient's respirations abnormally rapid (tachypnea) or unusually deep (hyperpnea)? Is there an abnormal respiratory pattern, such as Cheyne-Stokes respirations (rhythmic waxing and waning of the depth of the respirations with periods of apnea) suggesting a central nervous system (CNS) disorder?

The secondary survey of the respiratory system should begin with inspection. Look for the signs of respiratory distress, including:

- Nasal flaring: The nostrils will open wide on inspiration.
- Tracheal tugging: The Adam's apple will be pulled upward on inspiration.
- Retraction of the intercostal muscles: The patient will retract these muscles on inspiration.
- Use of the diaphragm and neck muscles: The patient will use the neck and diaphragm muscles exclusively on expiration.
- Cyanosis: If present, cyanosis (a bluish discoloration of the skin and mucous membranes) indicates relative hypoxia. Cyanosis is an unreliable sign, however, since severe hypoxia may be present without cyanosis being present.

Next, observe the chest wall. Has its anterior-posterior diameter increased (barrel chest), suggesting chronic obstructive pulmonary disease? Does the chest move symmetrically during respiration? During expiration, does any area bulge (flail)? Is the trachea in the midline, or does it deviate toward one side? In the trauma patient, is the chest wall deformed or discolored?

After observing the patient, auscultate the patient's chest. Listen first to the patient's breathing with the unaided ear; many abnormal respiratory sounds can be heard clearly without a stethoscope. Firmly apply the stethoscope to the patient's chest and listen, both anteriorly and posteriorly, to at least one respiratory cycle at each apex and each base.

Certain abnormal sounds detectable on auscultation of the lungs characterize different respiratory problems:

- Snoring is a familiar sound, occurring when the upper airway is partially obstructed by the base of the tongue. Snoring, and the obstruction it signals, can be corrected by the head tilt or triple airway maneuver. In both the base of the tongue is lifted from the back of the pharynx.
- Stridor is a harsh, high-pitched sound heard on inspiration that is characteristic of tight upper-airway obstruction, as in laryngeal edema. The "seal bark" of the child with croup is an example of stridor.
- Wheezing is a whistling sound heard diffusely in asthma and in some cases of pulmonary embolism and congestive heart failure. It is due to the narrowing of the airways by constriction (bronchospasm), edema, or foreign materials. Wheezes also can be heard when there is a foreign body obstructing the trachea or bronchus—for example, in the child who aspirates a peanut. Wheezing due to foreign bodies may be localized to the obstructed area. Therefore, listen carefully over all lung fields.
- Rhonchi are rattling noises in the throat or bronchi, often due to partial obstruction of the larger airways by mucus.
- Rales are fine, moist sounds, sometimes crackling or bubbling in quality, associated with fluid in the smaller airways (pulmonary edema, pneumonia). In cases of congestive heart failure, it is important to auscultate the bases of the lungs posteriorly because the rales of pulmonary edema usually are heard there first.

Determine whether breath sounds are equal on both sides of the chest. Diminished or absent breath sounds on one side mean that the lung on that side is not being adequately ventilated because of obstruction, collapse, or other causes.

Palpation of the chest follows auscultation. Feel the chest wall of the trauma victim for tenderness and instability over the ribs. Also palpate for subcutaneous emphysema or air in the subcutaneous tissues, which can be felt as a crackling sensation under the fingertips. If air invades the chest wall from the neck or the lungs, trauma to the chest can produce subcutaneous emphysema. Symmetry of breathing can be assessed by placing the thumbs on the xiphoid and spreading the hands over the anterior chest wall. If breathing is normal, move the hands symmetrically as the patient breathes. Palpation may also give clues to underlying lung disease. When a patient speaks, vibrations (vocal tremitus) may be felt on the chest wall. Normally, these vibrations are felt equally on both sides of the chest, but if air is not moving properly on one side of the chest—as in the case of an obstructed bronchus or pneumothorax—the vibrations will be absent or diminished on that side.

Percussion is the striking of a body surface to elicit a sound by which the density of the underlying tissue can be determined. Percussion of the chest wall often gives clues to underlying pathology. This process is accomplished by placing the tip of the third finger of one hand flat against the chest and striking it with the tip of the third finger of the other hand. In the normal individual, percussion of the chest produces a resonant sound, equal on both sides of the chest. In emphysema, when there is an increased volume of air trapped in the chest, the percussion note is diffusely hyperresonant. In pneumothorax, hyperresonance is heard over the side of the collapsed lung because there is no lung tissue to damp the sound. Consolidation of the lung (as in pneumonia) or fluid in the pleural space (hemothorax, hydrothorax), by contrast, will produce a dull percussion note, since there is less air in the affected side of the chest.

The patient with respiratory problems is not immune to abnormalities elsewhere. Therefore, complete the secondary head-to-toe survey.

## Putting It All Together

By the time the history and physical examination are completed, a great deal of information will have been obtained. But, this information will be useful only if you understand its relationship to various diseases and can form working hypotheses about what is wrong with the patient. Each bit of information derived from the history and physical exam must be used to support or to rule out the hypotheses.

For example, a patient has been in an automobile accident and thrown forward against the steering wheel. From the mechanism of injury, you suspect that the patient has suffered chest trauma. Your suspicion is supported when the patient relates chest pain and difficulty in breathing. These possibilities should be immediately apparent:

- The patient may have a simple pneumothorax. If so, breath sounds will be absent on the injured side, and that side will be hyperresonant on percussion.
- The patient may have a tension pneumothorax. Breath sounds will be absent on the injured side, and that side will be hyperresonant to percussion. Tracheal deviation, distended neck veins, and cyanosis will confirm this possibility.
- The patient may have blood in either pleural cavity (hemothorax). Breath sounds will be diminished or absent over the injury, and that side will be dull to percussion.

During the examination, you observe that breath sounds are normal on the right side, but absent on the left. Thus, the possibility of a simple pneumothorax on the right side is ruled out. The left chest during percussion emits dull sounds, compared with the right. This seems to rule out tension pneumothorax on the left. Your hunch is that the patient has blood or fluid in the left pleural space.

Patient assessment is basically detective work. As you take the history and perform the physical examination, you formulate hunches, look for clues, revise the hunches, and look for more clues. If you ask the right questions, the answers you receive will prove helpful.

## Unit 3. Pathophysiology and Management of Respiratory Problems

To perform a systematic evaluation of the patient with respiratory problems, an understanding of the respiratory system is necessary. The respiratory system comprises:

- **Central nervous system.** The CNS contains the respiratory center, which controls respiration.
- **Spinal cord, nerves, and muscles.** The spinal cord and nerves transmit messages from the respiratory center in the brain to the respiratory muscles.
- **Airways.** The pharynx, larynx, and bronchi transmit air to the lungs.
- **Alveoli.** The alveoli form the functional units of the lungs. where gas exchange occurs.
- **Pulmonary circulation.** The pulmonary vessels carry blood to the alveoli to pick up $O_2$ and to eliminate $CO_2$.

Damage or dysfunction in any one of these components can result in acute respiratory failure.

### Central Nervous System Dysfunction

Depression of the CNS, including depression of the respiratory center within, occurs in different ways. Head trauma can injure vital structures in the brain. Cerebrovascular accident or stroke can deprive parts of the brain of their blood supplies. Many drugs, particularly narcotics and barbiturates, also depress CNS activity.

Heroin overdose is a useful example of this type of respiratory depression. Such narcotics as heroin act as depressants on the respiratory center of the brain stem, producing respiratory insufficiency. Death from narcotic overdose almost invariably results from respiratory arrest.

These drugs make the respiratory center less responsive to increases in $PCO_2$ and depress the areas that control respiratory rhythm. Within minutes after a user takes an intravenous dose of heroin greater than the usual dose, the minute volume of respiration decreases (both tidal volume and respiratory rate fall). An increase in arterial $PCO_2$ accompanies this decrease in minute volume. At this stage, the patient's respiratory center may still be sensitive to the rise in $PCO_2$, and a transient increase in tidal volume and respiratory rate may occur. With progressive depression of the respiratory center, however, the brain sends fewer and fewer signals to the respiratory muscles, and the minute volume again falls, with an associated rise in $PCO_2$.

Depending on the amount of the drug taken, the patient is at first likely to be stuporous or deeply comatose. The respiratory rate will be very slow (perhaps only 2 to 4 respirations per minute), and there may be extended periods of apnea (absence of respirations). Like any comatose patient, the patient in a heroin overdose coma is likely to have either a partially or completely obstructed airway. Blood pressure is often low, and the skin is cold and clammy.

Specific treatment of heroin overdose is discussed in detail in Module X. Yet, there are basic principles of management that apply to any patient with respiratory insufficiency secondary to CNS depression. For patients in this condition:

- Establish an airway.
- Determine whether the patient is breathing. If the patient is not breathing, or if respirations are very slow and shallow, assist ventilations with a bag-valve mask.
- Administer oxygen.
- Establish an intravenous (IV) line.
- Secure the airway with an endotracheal tube. This is particularly important if the patient is deeply comatose and has lost the protective reflexes that normally guard against aspiration (cough, gag, etc.).

Further treatment will vary, depending on the underlying problem, but the forementioned are most important life-support measures in all respiratory depression cases related to CNS dysfunction.

### Dysfunction of Spinal Cord, Nerves, or Respiratory Muscles

Trauma or disease of the respiratory muscles or the nerves that supply them can result in acute respiratory insufficiency. Injury high in the spinal cord can result not only in quadriplegia but also in the paralysis of the muscles of respiration. Such illnesses as polio can damage the nerves that supply the respiratory muscles, and such chronic conditions as myasthenia gravis (muscular fatigue and exhaustion) often cause weakening of the respiratory muscles themselves. In all of these cases, the result is the inability of the respiratory muscles to contract normally in response to the respiratory drive. Therefore, the tidal volume is shallow, and the minute volume is decreased correspondingly. Patients with such conditions often need ventilatory support.

When treating these types of patients, you must first establish an airway. When treating the patient with a cervical spine injury, for example, you must establish an airway without extending the patient's neck unduly and worsening the injury. If respiration is shallow, assisted ventilation with a bag-valve mask or demand valve is called for.

## Airway Problems

The management of upper and lower airway obstruction is discussed in this section. Emphasis will be given to the tongue and foreign bodies blocking the airway, airway trauma and edema, emphysema, bronchitis, and asthma.

### Upper airway obstruction.

The most common source of upper airway obstruction is the tongue, which tends to fall back against the posterior wall of the pharynx, particularly in the comatose or stuporous patient. The patient whose airway is obstructed by the tongue will have snoring respirations. This type of obstruction can be relieved by the backward tilt of the head, the chin lift, or the triple airway maneuver—tactics that elevate the base of the tongue away from the back of the throat. An oropharyngeal or nasopharyngeal airway tube can be used on the comatose patient. Conscious patients seldom tolerate these devices and seldom need them.

Foreign bodies can also be the cause of upper airway obstruction. According to the National Safety Council, an estimated 2,500 people die annually while eating, and an unknown proportion of these choke on food stuck in their throats. The typical victim of the so-called cafe coronary is middle-aged or elderly and often wears dentures. The victim usually has had a few alcoholic drinks. (Alcohol tends to depress the protective reflexes and affect judgment about the appropriate-sized pieces of food. One piece of meat extracted from the throat of a choking victim at autopsy was over 8 inches long.) When a piece of solid food, often a chunk of meat, lodges in the airway, the victim becomes completely aphonic—unable to talk, breathe, groan, cough, or cry out. The patient may try to get up from the table or may pitch forward, all in complete silence.

The most effective treatment for the patient with food lodged in the upper airway is to use a laryngoscope to view the larynx while removing the obstruction with a Magill forceps, Kelly clamp, finger, or strong suction.

If a choking victim is conscious:

- Prevent the patient from running away from help. (Choking patients who panic may stagger about.)
- Encourage the patient to cough.

The appendix at the back of this module provides detailed instructions for handling the choking patient who is sitting or standing.

If you encounter a choking patient who may have aspirated a foreign body, take the following steps:

- Try to ventilate the patient. If unsuccessful, roll the victim prone and deliver four sharp blows between the shoulder blades.
- If still unsuccessful, try ventilation again.
- Roll the victim back to the supine position and forcefully press both hands, one on top of the other, into the upper abdomen about four times.
- Manually clear airway.
- Try ventilation.
- Repeat procedure if necessary.

No matter what technique you use to relieve airway obstruction, remember that time is essential. Death from asphyxia takes about 5 minutes. Do not waste valuable time hunting for equipment or deciding what to do. Begin treatment immediately; an assistant can run back to the emergency vehicle to get necessary equipment.

If the patient is already in the late stages of asphyxiation, muscular rigidity may have set in and the jaws may be clenched. In such cases and when the other maneuvers described have failed and equipment for direct laryngoscopy is unavailable, cricothyroidotomy may be performed as a last resort. This technique, involving puncture of the cricothyroid membrane, is described in detail in Unit 4.

When dealing with a choking infant or small child, use the time-honored technique of holding the victim upside down while sharply slapping the back. Abdominal compression can seriously injure the liver and other abdominal organs of infants and small children and should only be used as a last resort.

A child's upper airway can also become obstructed by swelling of its tissues. For example, with the childhood disease croup, comes edema of the loose tissues immediately beneath the vocal cords. This often causes airway obstruction. Epiglottitis in children leads to marked swelling of the epiglottis and pain on swallowing and may cause complete airway obstruction.

In adults, laryngeal edema can occur from burns of the airway and from allergic reactions. An example of this kind of problem is angioneurotic edema, a reaction that occurs in sensitive individuals upon exposure to foods or other substances to which they are allergic. The patient with an allergy to a specific food will usually report an itching sensation in the palate followed by the sensation of a lump in the throat. Hoarseness develops, progressing rapidly to cough and inspiratory stridor. Urticaria (hives) may also be present. As respiratory distress becomes more marked, retraction of the intercostal and neck muscles becomes evident on inspiration as well. Emergency management is aimed at reversing the swelling and improving oxygenation:

- Establish an airway.
- Administer oxygen.
- Give epinephrine (1:1,000), 0.2 to 0.5 ml subcutaneously (SC). The dose may be repeated in 10 to 20 minutes as necessary.
- Give diphenhydramine (Benedryl), 25 mg intramuscularly (IM).
- Start an IV line.

Patients with severe airway obstruction who do not respond promptly to epinephrine and antihistamines may require an emergency airway. Direct laryngoscopy is the easiest, safest, and best way to establish an airway. If the cords are blocked and the object cannot be removed or the cord spasm broken with Magill forceps, cricothyroidotomy should be performed.

Upper airway obstruction can also be caused, secondary to trauma of the face and neck. Facial trauma can cause airway obstruction from collapse of the mandible, hemorrhage, tongue injury, aspiration of tissue, aspiration of teeth or dentures, or accompanying coma. The strategy for management will depend on the location of the trauma and extent of related injuries. The patient's whole body should be rolled laterally while axial traction on the head is maintained so that blood will drain out of the patient's mouth rather than down into the airway. Suctioning can remove blood and small particles from the upper airway. If the trauma primarily involves the mandible, a nasopharyngeal airway may be useful. Trauma to the neck can cause laryngeal fracture or contusion and may require urgent cricothyroidotomy.

In summary, the upper airway can be obstructed by the tongue or foreign bodies, by swelling of structures within the airway, or by trauma to the airway. In all cases, an obstructed airway is a dire emergency. For this reason, evaluation of the airway is the first step in the primary survey of all patients.

## Obstructive airway diseases.

In obstructive airway diseases there is diffuse obstruction to airflow within the lungs. The most common of these diseases are emphysema, chronic bronchitis, and asthma. The incidence of these diseases is very high in the United States: Between 10 and 20 percent of the adult population suffers from them. These conditions are often classified together as chronic obstructive pulmonary disease (COPD) or chronic obstructive lung disease (COLD).

## Emphysema and chronic bronchitis.

These illnesses are much more common in men than in women, and they strike city dwellers more often than rural inhabitants. The most important contributing factor to COPD is cigarette smoking; urban air pollution also plays a role, but is less significant.

Emphysema is a pulmonary condition in which the air space beyond the terminal bronchioles are increased in size, because of the destruction of the alveolar walls. Alveolar wall breakdown has several effects. First, it increases the ratio of air to lung tissue in the lung. Second, it weakens the walls of the small bronchioles. Third, it decreases the alveolar membrane area, thus decreasing the area available for gas exchange. Fourth, it decreases the number of pulmonary capillaries in the lung, thereby increasing resistance to pulmonary blood flow.

Because alveolar walls are destroyed, the lungs hold more air. Therefore, respiratory volumes increase, in particular the residual volume—the amount of air remaining in the lungs at the end of a maximal respiration. In contrast, the vital capacity—the amount of air exhaled in a maximal expiration following a maximal inspiration—remains fairly normal until emphysema is far advanced.

When, within the lung, the ratio of air to tissue is increased characteristic physical signs become evident. Because air is a poorer carrier of sound than is tissue, breath sounds decrease in emphysema. And because an overinflated lung is located between the chest wall and the heart, it is harder to hear heart sounds and to feel the impulse at the heart apex. An overinflated lung is also hyperresonant to percussion.

Destruction of the alveolar walls also weakens the walls of the small bronchioles, thus lengthening expiration.

Decreased alveolar membrane area impairs gas diffusion across pulmonary membranes. However, good resting gas exchange is maintained by increased respiratory effort until emphysema is far advanced. During emphysema's beginning stages, arterial $O_2$ saturation is only slightly decreased and pH remains fairly normal.

In further advanced emphysema, arterial $PO_2$ decreases. This decrease may lead to increased red blood cell production, which will raise hemoglobin levels, and increase the amount of oxygen that can be transported at a given $PO_2$ level. Carbon dioxide retention also is symptomatic of advanced emphysema.

In the late stage of the disease, there is increased resistance to blood flow through the pulmonary vessels. This situation occurs because pulmonary blood vessels are destroyed along with the alveolar walls. Increased resistance to pulmonary blood flow leads to right heart failure, with liver enlargement, neck vein distention, and ankle edema.

Pulmonary emphysema leads to three potentially fatal complications: right heart failure, acute respiratory infection that causes hypoxia and hypercarbia, and cardiac arrhythmias resulting from hypoxia or hypercapnea. Often, the patient with emphysema is thin, having recently lost weight, and complains of increasing shortness of breath on exertion and of progressive limitation of physical activity. Usually, coughing is not prominent and, when it occurs, produces only small amounts of whitish-gray, mucuslike sputum. Patients with emphysema maintain fairly normal arterial blood gases and, therefore, are not usually cyanotic.

Physical examination of the emphysema patient will reveal a chest that is hyperresonant to percussion because of air trapped in the lungs. The patient with far-advanced emphysema has decreased chest excursion, hypertrophied accessory respiratory muscles, and breathes with pursed lips. Clubbed fingers are another sign of advanced emphysema.

Chronic bronchitis, a clinical diagnosis, is a pulmonary condition where for most days of at least 3 months of 2 consecutive years mucopurulent sputum is produced. Mucopurulent sputum is composed of mucus and pus. In chronic bronchitis, increased numbers of mucus-secreting cells in the respiratory epithelium produce the characteristically large amount of sputum.

Diffusion across pulmonary membranes remains normal since chronic bronchitis does not seriously affect the alveoli. But the alveolar hypoventilation that accompanies chronic bronchitis adversely affects respiratory gas exchange. This leads to arterial hypoxia and carbon dioxide retention. Arterial hypoxia can cause increased red blood cell production, which in turn can increase the $O_2$-carrying capacity of the blood. Patients with chronic bronchitis tend to adjust to increased $PCO_2$ levels. Their respiration is regulated by decreases in $PO_2$. The increased $PCO_2$ levels found in chronic bronchitis, however, constrict the pulmonary circulation. This situation increases the work of the right ventricle and leads to right heart failure.

Brain function can also be altered by increased $PCO_2$ levels—leading to irritability, decreased intellectual abilities, headaches, and personality changes. Hypercapnea above 60 torr causes dilation of cerebral blood vessels and increases cerebral blood flow. Cerebrospinal fluid pressure may also increase leading to stupor and coma. In chronic bronchitis, acute and chronic infections produce scarring in the lungs. Vital capacity is decreased, and residual volume is normal or decreased. Thus patients with chronic bronchitis have normal or decreased total lung capacity.

Almost invariably, patients with chronic bronchitis have been heavy cigarette smokers and, in their forties, usually begin suffering from severe respiratory problems. Before this, they will have had, generally, many respiratory tract infections. Even between acute infections, chronic bronchitis patients normally produce at least 10 ml of green or yellow sputum daily. Like patients with emphysema, patients with chronic bronchitis have prolonged expiration, but they also have inspiratory airway obstruction. Coarse rales, rhonchi, and wheezes may be heard through both lung fields. Because the overinflated lungs are not located between the heart and the chest wall, heart sounds are heard more easily in chronic bronchitis than in emphysema. And right ventricular enlargement resulting from right heart failure is often detectable on physical examination. If so, an impulse representing right ventricular contraction can be felt between the sternum and the heart apex in the third, fourth, or fifth intercostal space. Other physical signs of right heart failure are distended neck veins, enlarged liver, and ankle edema. Pure pulmonary emphysema and chronic bronchitis represent two extremes of a single spectrum. Both conditions can occur in the same patient, producing signs and symptoms intermediate between the two extremes.

Patients with COPD are vulnerable to episodes of acute decompensation accompanied by respiratory failure. These episodes are often triggered by a respiratory infection. The patient may notice that sputum becomes more purulent and increases in volume. The patient's shortness of breath increases, often enough so that it disturbs sleep. Increasing hypoxia leads to cyanosis, confusion, agitation, and sometimes muscular twitching. Right heart failure can also occur, accompanied by peripheral edema and jugular vein distention.

Management of COPD patients in acute respiratory failure is aimed at relieving hypoxia. Many of them breathe because of hypoxic drive. Therefore, $O_2$ administration may take away their stimulus to breathe and result in apnea. Supplemental $O_2$ should not be withheld from these patients, however, as they may die without it. Knowing that $O_2$ administration may depress the patient's respiration, be prepared to assist the patient's ventilations if necessary. The general principles of management of COPD patient in respiratory failure are presented below:

- Establish an airway.
- Place the patient in a sitting or semisitting position.
- Administer $O_2$. Monitor the patient's respiratory rate and depth and assist ventilations should respirations become depressed.
- Establish an IV line with 50-percent dextrose in water (D5W) to keep an open rate.
- Administer aminophylline if ordered by physician by adding 250 mg of aminophylline to a 250-ml bag of D5W, at a rate of 100 ml per hour. This rate is generally safe.
- Do not give sedatives or tranquilizers. If the patient is agitated or confused, hypoxemia and hypercarbia are probably the reason. Sedative drugs only depress respirations further, worsening hypoxia and hypercarbia.
- Encourage the patient to cough up any secretions.

### Bronchial asthma.

Bronchial asthma is characterized by an increased reactivity to some stimuli of the trachea, bronchi, and bronchioles, with widespread, reversible narrowing of the airways (bronchospasm). The disease afflicts approximately 6 million Americans—4,000 to 5,000 die from asthma each year. Asthma begins before age 10 in about 50 percent of the cases, and before age 30 in another 33 percent. Often, more than one member of a family has the disease. Asthma characteristically produces acute attacks of varying duration. Between attacks, the patient may be relatively symptom free.

The acute asthma attack reflects airway obstruction due to bronchospasm, swelling of the mucous membranes in the bronchial walls, and plugging of the bronchi by thick mucus secretions. The attack may be brought on by an allergic reaction to inhaled irritants, by respiratory infection, or by emotional stress. Narrowing of airways and increased amounts of tenacious sputum interfere with airflow, especially on expiration. Airway constriction and increased amounts of sputum result in progressive hyperinflation of the chest, and the patient experiences increased difficulty moving air in and out.

In the typical acute attack, the patient is found sitting up, often leaning forward, and fighting to breathe. The patient may be coughing spasmodically and unproductively. Use of accessory muscles of respiration is prominent, and the chest is relatively fixed in the inspiratory position. Wheezing is usually audible even without a stethoscope, but may be absent if the attack is very severe, and there is very little movement of air. The chest is hyperresonant to percussion because air is trapped in the lungs.

Management of the acute asthmatic attack is aimed at relieving bronchospasm and improving ventilation. Before administering any medication to the asthmatic, however, find out what the patient has already taken. (For example, the physician may hesitate to order epinephrine for an asthmatic who has already taken a near overdose of a related drug from a pocket inhaler.) Assuming that that patient has not taken a large amount of medication before the paramedic arrives, the general principles listed below for managing the acute attack should be followed:

- Establish an airway.
- Administer humidified oxygen. If available, an IPPV device is preferable. The unmodified demand valve is a poor second choice because it delivers dry gases to the airway and, thus, tends to worsen the already thick secretions. A nebulization unit attached inline to the bag-valve mask may be very useful in such circumstances. Ask a respiratory therapist at the hospital for help in rigging up such a device for the ambulance.
- Establish an IV line with D5W. In an adult patient without signs of heart failure, run the IV side open.
- Administer epinephrine (1:1,000), 0.3 to 0.5 ml SC (adult dose). This dose can be repeated in 30 minutes, if necessary.
- If ordered by a physician, administer aminophylline in a dose level of 250 ml to a 250-ml bag or bottle of D5W. Piggyback this infusion into the IV and run it at the rate specified by the physician, usually around 100 ml per hour.
- Administer bronchodilators such as epinephrine, isoproterenol (Isuprel), and isoetharine (Bronkosol) by aerosol. But remember that the decision whether to use any of these agents depends in part on how much, if any, bronchodilator the patient has already inhaled.
- Do not give sedatives or aspirin. (The specific details of management of acute asthmatic attacks in children are discussed in Module 12.)

Status asthmaticus is a severe, prolonged asthmatic attack that cannot be broken with epinephrine; the condition is a serious medical emergency. Upon examination, the patient's chest will appear to be distended greatly. The patient will fight desperately to move air through the obstructed airways and make prominent use of accessory muscles of respiration. Breath sounds and wheezes may be absent because there is little air movement. The patient is usually exhausted, severely acidotic, and dehydrated. The principles of management are similar to those for the acute asthmatic attack, but there is much greater urgency in starting therapy and getting the patient to the hospital. In some cases, it is desirable to administer a sodium bicarbonate IV to counteract acidosis.

When dealing with any asthmatic patient, it is important to maintain a calm, reassuring attitude to lessen the considerable anxiety associated with difficulty in breathing.

A note of caution: All wheezing is not asthma. Among the many other causes of diffuse wheezing are acute left heart failure (cardiac asthma), smoking inhalation, chronic bronchitis, and acute pulmonary embolism. Localized wheezing reflects an obstruction by a foreign body or a tumor in a specific area. Only a careful history and physical examination will enable you to make the correct diagnosis. Because the two conditions demand different treatments, you must be able to distinguish between the wheezing due to asthma and that due to left heart failure. Table 5.1 tells how they differ.

## Problems Affecting Alveolar Function

Atelectasis, or collapse of alveoli, may result from internal or external causes. The principal internal cause of atelectasis is obstruction. When an airway becomes obstructed, the gases in the alveoli beyond the obstructed airway are gradually absorbed, and the alveoli collapse. The alveoli cannot reexpand until the obstruction is removed. Thus, the asthmatic or chronic bronchitic with mucus plugs in the smaller bronchi may have numerous areas of alveolar collapse. Similarly, the child who has aspirated a peanut into a mainstem bronchus may have an entire collapsed lung. In alveolar collapse, deviation of the trachea will be toward the absent breath sounds rather than away from them as in tension pneumothorax (air in the pleural space).

External causes of atelectasis are those that prevent adequate lung expansion, such as pneumothorax, fluid in the pleural space (pleural effusion, hemothorax), gastric distention (which compresses the bases of the lungs upward), pain (which inhibits patients from taking deep breaths), and flail chest. In the field, these external causes of atelectasis are most often seen following chest trauma.

When an alveolus is collapsed, the blood passing through the adjacent pulmonary capillaries does not pick up any $O_2$. Instead, the blood returns to the left heart with a low $PO_2$—an effect known as shunt. If a large number of alveoli are collapsed, then a large proportion of the blood circulating through the lungs will return to the left heart unoxygenated. This condition will cause arterial hypoxia. Therefore, until proven otherwise, assume that any patient having significant atelectasis—whether from obstruction, chest trauma, gastric distention, or other causes—also has a significant hypoxia. Give such patients $O_2$.

Trauma to the chest can result in two different types of injuries: deceleration injuries and compression injuries. Newton's first law of motion states that a body at rest or a body in motion will continue in that state until acted upon by some outside force. An automobile moving down the highway will continue to move forward until the brakes are applied or until some obstruction—a telephone pole or tree, for example—is encountered. The contents of the thoracic cavity will likewise continue forward until the thoracic cage meets a sudden obstruction, like an automobile steering wheel or a dashboard.

The thoracic aorta is fixed at three points—at the aortic valve, the ligamentum arteriosum, and the diaphragm. The rest of the aorta is mobile and, following Newton's law, will continue moving forward while these three areas are held stationary. If the deceleration forces are stronger than the structures of the aorta, tears will occur. As the head of pressure in the aorta is significant, exsanguination occurs in 85 to 90 percent of the cases. In 10 to 15 percent, however, the hemorrhage will be contained as a pseudoaneurysm protected by the supporting tissue of the aorta, and the patient will be delivered to the hospital alive. The obscurity of the condition and its lack of overt physical findings make diagnosis somewhat difficult. Hoarseness, indicating recurrent laryngeal stretching, or absent pulses in the left arm or the legs are warning signs of this condition. Absolute diagnosis can be made by mediastinal enlargement noted on chest film and aortogram.

Deceleration injuries to the heart are relatively rare. They do occur, but because the sternum effectively limits anterior motion, only side impacts present a danger. But even when they occur, the mediastinum serves to protect the heart.

Seven compression injuries will be discussed in this section: rib fractures, flail chest, pneumothorax, sucking chest wound, tension pneumothorax, hemothorax, and ruptured bronchi.

### Table 5.1.—How Asthma and Left Heart Failure Differ

| *Item* | *Asthma* | *Left Heart Failure* |
|---|---|---|
| History | Often a younger patient | Often an older patient. |
| | May have allergic history or family history of allergy | May have history of heart problems or hypertension. |
| | Previous attacks of acute, episodic dyspnea | May have symptoms of acute myocardial infarction. |
| | May have had recent respiratory infection | Dyspnea worse when lying down (orthopnea). |
| | | Recent rapid weight gain. |
| | Unproductive cough | Cough with watery or foamy sputum. |
| | Possible wheezing | Wheezing. |
| Medication | Inhalers—Medihaler, Vaponephrin, Micronefrin, Isuprel | Digitalis—digoxin Lanoxin, digitoxin. |
| | Pills—Tedrol, Sudafed, Quibron, Marax, Actifed | Diuretics—Diuril, Esidrix, Lasix, Edcrin, Naqua. |
| Physical Findings | Chest hyperinflated and hyperresonant to percussion | Rales $S_3$ gallop. |
| | Use of accessory muscles to breathe | Distended neck veins. |

Just as the front of an automobile is damaged when it collides with a tree or a bridge abutment, the front of the thoracic cage and the contents of the thoracic cavity can be damaged when the chest forcefully strikes an obstruction.

When the thoracic cavity is damaged, ribs may be broken. The damage may be limited to a simple fracture occurring near the impact. But because the ribs are a part of a ring, a break at one point without a bend or a fracture at another point is unlikely. Thus, you must assume that ribs are fractured in several places or that there is separation of the costal muscles.

Fractured ribs alone create problems because of the associated pain. This pain causes the patient to splint that portion of the chest—that is, to decrease expansion of the underlying alveoli. This condition can lead to atelectasis and later to pneumonia. Therefore, fractured ribs should be supported by taping or other methods of external splinting for only a few hours. Control the associated pain with medication or nerve blocks.

Flail chest results when two or more adjacent ribs are fractured in two or more places, resulting in a segment of the thoracic cage becoming detached. When this occurs, adequate lung expansion cannot be accomplished. The loose segment will move out with increased pulmonary pressure (expiration) and will move inward with decreased pulmonary pressure (inspiration). This situation effectively decreases the amount of lung excursion. The movement of air is, therefore, compromised as is the pulmonary oxygenation. This condition is known as paradoxical respiration.

### Table 5.1.—How Asthma and Left Heart Failure Differ—Continued

| Item | Asthma | Left Heart Failure |
|---|---|---|
| | Silent chest if bronchospasm is severe | Pedal/presacral edema. |
| Treatment | Humidified $O_2$ | $O_2$. |
| | IPPV | IPPV. |
| | Monitor | Monitor. |
| | IV D5W or D5NS wide open | IV D5W to keep open |
| Drugs Indicated | Epinephrine, aminophylline, occasionally bicarbonate | Morphine, diuretics, occasionally aminophylline. |
| Drugs Contraindicated | Morphine, diuretics | Epinephrine, usually bicarbonate. |

Since paradoxical respiration can produce hypoxia and severely compromise lung function, the detached segment must be stablized. The simplest method is to immobilize the segment in its inward position by taping sandbags or a pillow over it. Use your hand until these devices can be found.

The diagnosis of a flail chest is made by either observing or palpating the paradoxical movement of the loose segment. This can be done only by removing the patient's clothes from the waist up and carefully examining the chest—look, listen, and feel.

Compression injuries also can involve the internal thoracic structures of the heart and lung. Pneumothorax is an accumulation of air in the pleural space that limits lung expansion (see Figure 5.5). This air can come from outside the chest cavity, as in a sucking chest wound, or from within, as in a laceration of the lung.

Sucking chest wounds occur as a result of external penetrating trauma that produces a laceration of the chest wall preventing inward movement of air. Sucking chest wounds can lead to hypoxia. The laceration should be covered with a nonporous material like Vaseline gauze, cellophane, or plastic wrap.

After closing the wound, be constantly alert to the development of tension pneumothorax. Should such a condition develop, provide relief by removing the occlusive dressing during expiration and reapplying it during inspiration. This allows decompression of the tension pneumothorax.

Lacerations of the pulmonary pleura can result from three types of injury:

- The penetrating missile that caused the sucking chest wound can continue inward, damaging the alveoli and allowing air to pass from the major bronchi through the secondary bronchi and out into the pleural space.
- A fractured rib can penetrate the parietal pleura damaging the lung surface.
- Forceful compression of the inflated lung by a stationary object, like an automobile steering wheel or dashboard, increases intrapulmonary pressure and can tear the lung. As the external force is reduced and the thoracic wall rebounds, air is sucked through the laceration producing a pneumothorax. This type of injury is caused by the so-called paper bag effect: Realizing that a collision is about to occur, many people instinctively take a deep breath, inflating their lungs and closing their glottises. In this state, the inflated lungs resemble a blown-up paper bag and are prone to injury.

No matter what the etiology, the pathophysiology of pneumothorax is the same: an accumulation of air in the pleural space. If a portion of the pleural cavity is filled with air, the lung cannot expand into it. Alveolar ventilation is, therefore, compromised. As long as

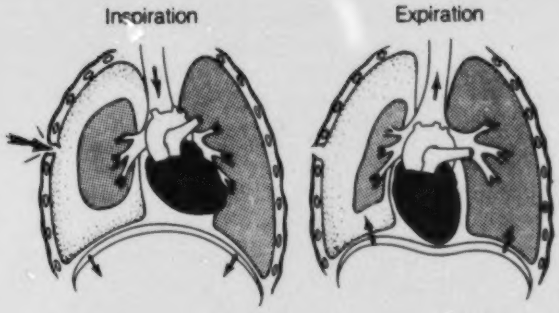


**Figure 5. Pneumothorax**

this space maintains its stability and is not enlarged, most individuals can tolerate for a limited period of time compromise approaching 100 percent of one lung. But if the space enlarges for any reason, major complications can result:

- Shifting of the mediastinum away from the increased intrapleural pressure, which will compromise the alveolar ventilation on the opposite side.
- Kinking of the superior and inferior vena cava, reducing blood flow into the heart, and thereby diminishing cardiac output and increasing the venous pressure. This condition is known as a tension pneumothorax (see Figure 5.6).

Diagnosis of a tension pneumothorax is made by looking for the obvious signs that would be expected from the pathology:

- Cyanosis.
- Absent breath sounds on the ipsilateral (affected) side.
- Tracheal deviation to the contralateral (opposite) side.
- Distended neck veins.

Accumulation of air in the subcutaneous tissues is called subcutaneous emphysema. This condition can be associated with any pneumothorax and is particularly associated with tension pneumothorax. On palpation of the chest, subcutaneous emphysema produces a crackling sensation, as small bubbles of air move from one compartment into another. Subcutaneous accumulation of air is a particularly important sign indicating that the pressure within the pleural cavity is great enough to force air into the subcutaneous tissues. This condition presages the possibility of a tension pneumothorax.

Tension pneumothorax can lead rapidly to anoxia (lack of oxygen in the body tissues) and decreased cardiac output. It is imperative, therefore, that tension pneumothorax be treated as quickly as possible. Relieve the pressure by passing a large-bore catheter or needle into the midclavicular line of the second intercostal space on the affected side. Use a flutter valve-catheter arrangement if one is available.

A laceration of the internal thoracic artery, intercostal artery, aorta, vena cava, or other intrathoracic vessel will produce an accumulation of blood within the pleural space. This condition is known as hemothorax. Hemothorax can lead to the compromise of alveolar filling and to blood loss resulting in hypovolemia, hypotension, and shock. Field evacuation of a hemothorax, is not advisable, however, because the blood can be used for autotransfusion and its evacuation can lead to further bleeding. Evacuation of a hemothorax should be accomplished only when replacement with whole blood is available.

Pneumothorax can be secondary to ruptured or lacerated bronchi. Pulmonary contusions can occur on the lungs just as on any other part of the body. Therefore, keep a constant watch for the signs of decreasing alveolar absorption of air, which may be caused by intra-alveolar hemorrhage.

When alveoli fill with pus, as in pneumonia, they become nonfunctional. Like the collapsed or fluid-filled alveolus, the consolidated alveolus does not participate in gas exchange. This situation contributes to shunt. Hypoxemia may result.

Pneumonia is caused by bacteria, viruses, or fungi. The pneumonia patient usually reports several hours to several days of fever, weakness, and productive cough, and sometimes chest pain worsened by coughing. The illness can announce itself abruptly, with a shaking chill, or set in gradually, progressively weakening its victim. The elderly and those with chronic diseases are more prone to pneumonia than are younger, healthier persons.

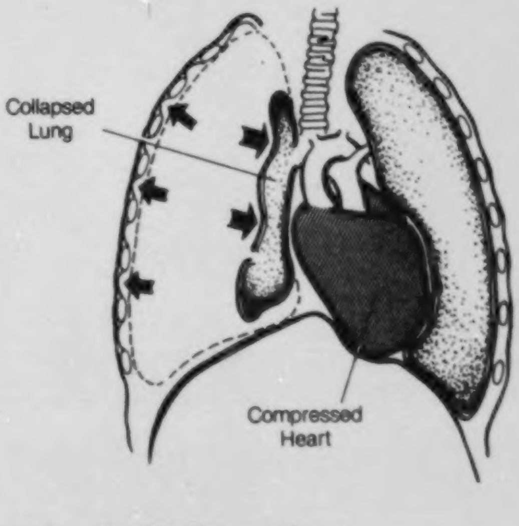


**Figure 6. Tension Pneumothorax**

The pneumonia patient is often feverish and coughing and may exhibit minimal or marked respiratory distress, depending on the degree of pulmonary consolidation. Auscultation of the chest will reveal rales and rhonchi over the affected lung. Areas of the lungs may sound dull to percussion.

Definitive treatment of pheumonia requires hospitalization. In the field, not much can be done. Administer $O_2$ and transport the patient in a comfortable position.

Another source of alveolar dysfunction is pulmonary edema—the accumulation of fluid in the pulmonary interstitial tissue and the alveolar air spaces. Fluid accumulates between the alveolar capillaries and alveolar air, hampering gas exchange. Pulmonary edema will also occur in left heart failure. Because the left heart no longer efficiently pumps blood to the systemic circulation, pressure rises in the pulmonary blood vessels. Aspiration of irritants, inhalation of toxic fumes, drowning, and heroin overdose are other causes of pulmonary edema.

Approximately 6,500 people in the United States die each year by drowning, making it the fourth leading cause of accidental death. Among adults, alcohol intoxication is a factor in about one-third of the cases. When treating the near-drowning victim, keep these points in mind:

- As the victim goes under, water enters the mouth and nose, and he or she begins to cough and gasp and to swallow large amounts of water.
- A small amount of water is aspirated into the larynx and trachea, setting off spasms of the laryngeal muscles (laryngospasm). In 10 percent of the victims, laryngospasm seals off the airway and temporarily protects it from further aspiration. In the other 90 percent, water enters the lower airways and laryngospasm offers no protection.
- Laryngospasm or aspirated water leads to asphyxia. Asphyxia produces arterial hypoxia and $CO_2$ retention. The near-drowning victim develops both respiratory and metabolic acidosis. Respiratory acidosis results from lactic acid accumulation in $O_2$-depleted tissues. When hypoxia becomes severe, the victim loses consciousness.
- Subsequent pathophysiology of drowning is affected by the type of water that the victim aspirates. Water will cross a semipermeable membrane from a solution of lower concentration to a solution of higher concentration (osmosis). The junction between the alveolus and the pulmonary capillaries acts like a semipermeable membrane. Fresh water has a lower soluble concentration than blood; salt water is more concentrated. Therefore, if the victim aspirates fresh water, it rapidly crosses the alveolar membranes into the bloodstream. The blood, as a result, may become diluted and its electrolyte balance may become upset.

When the victim aspirates salt water, fluid is drawn into the alveoli from the bloodstream, causing serious pulmonary edema. Pulmonary edema mechanically obstructs gas exchange across the pulmonary membranes. Therefore, greater hypoxia occurs with salt-water aspiration than with fresh-water aspiration.

These conditions are superfluous, however, if the patient is still under the water. Cardiovascular problems, as well as respiratory problems, occur in near drowning. Cardiac arrhythmias, which can lead to cardiac arrest, result from hypoxic electrolyte disturbances. Fluid overload in fresh-water victims and hypovolemia in salt-water victims can also produce cardiovascular problems.

Whether near-drowning occurs in fresh water or in salt water, initial resuscitation involves standard cardiopulmonyary resuscitation techniques. First, try to reach the victim without endangering yourself. (An unqualified swimmer should not try to rescue a drowning victim because the rescue attempt may lead to two drowning victims.) After reaching the victim, establish an airway and begin ventilation—even before the victim is removed from the water. Do not waste time trying to remove water from the victim's lungs early in resuscitation. If the near drowning occurred in fresh water, water will have already been absorbed through the lungs. Even in salt water near drownings, laryngospasm may have protected the lower airway from aspiration. When dealing with a swimming pool near drowning, assume that the patient is a victim of a diving accident and protect the cervical spine while both giving mouth-to-mouth resuscitation and removing the victim from the water.

After removing the victim from the water, determine whether a pulse is present. Begin closed chest compression if it is needed. Early endotracheal intubation is desirable to permit positive-pressure ventilation. It also protects the airway from aspiration during vomiting, which usually occurs during resuscitation from near drowning. Supplemental $O_2$, in the highest possible concentration, should be administered as soon as it is available. The use of an oxygen-powered, positive pressure resuscitator is particularly advantageous in this regard. Suctioning should be carried out as needed.

Once an endotracheal tube is in place, insert a nasogastric tube to decompress the stomach. Further advanced life-support measures resemble those employed in cases of cardiopulmonary arrest—establish an IV route, administer bicarbonate and epinephrine, monitor the heart rate and rhythm, and electrically convert ventricular fibrillation.

Near-drowning victims tend to develop extreme acidosis and may initially require more bicarbonate than the usual cardiac arrest patient. Two ampules of bicarbonate—100 milliequivalents (mEq)—should be given push as soon as the IV line is started, followed by 50 mEq every 10 minutes for the duration of the arrest.

Although hypovolemia may be significant following salt-water aspiration, crystalloid solutions, which readily leave the circulation, will worsen the pulmonary edema. Plasma substitutes may be used for fluid resuscitation because they correct hypovolemia with less aggravation of the pulmonary edema. When transporting the patient to the hospital over a long distance, large doses of steriods may be indicated to protect the pulmonary tree.

Even if it appears that patients have recovered at the scene, transport them to the hospital. Delayed deaths can occur in near drowning due to pulmonary edema and aspiration pneumonia. Evaluate the condition of the lungs or adequacy of arterial oxygenation at the scene. The patient should receive 100 percent $O_2$ during transport and should also be given resuscitation if it is needed.

Near drownings in cold water (less than 70° F) are of interest because of the cold's effect in prolonging survival time. Many patients have been resuscitated without residual neurologic problems after immersions of 4 to 45 minutes. In general, successful resuscitations are related to age, water temperature, duration of immersion, and water cleanliness. The younger the patient, the colder and cleaner the water, and the shorter the time of immersion, the better the chances are for successful resuscitation.

Two physiologic mechanisms are proposed to account for the long survival times of near drownings in cold water. The first is the relatively rapid onset of hypothermia in patients in cardiopulmonary arrest who are submerged in cold water. The cold exerts a protective effect on the brain and other tissues, decreasing the rate of cellular degeneration that results from anoxia at normal body temperatures. The second is the mammalian diving reflex, in which the body redistributes blood flow from nonessential tissues (e.g., extremities) to vital organs (lungs, heart, and brain). The diving reflex occurs when the face is immersed in cold water. It is particularly strong in infants and children, which may help to explain the greater success of resuscitation in young patients.

Fatal burns to the respiratory tract can occur with little or no external evidence. Toxic combustion products and inhaled chemical irritants produce varying amounts of damage depending on the nature and duration of exposure. Inhalation of superheated air by itself rarely damages the lungs, because dry air conducts heat poorly and the mucous membranes of the upper respiratory tract efficiently cool the air. Furthermore, a blast of hot air causes reflex closure of the vocal cords, thus further reducing the possibility of direct thermal injury to the lower respiratory tract. Only the inhalation of steam is likely to cause thermal injury to the lung mucosa. Combustion products of some common substances, however, are very toxic to airways and alveoli and cause upper airway obstruction (due to edema), bronchospasm, and damaged pulmonary capillaries, allowing fluid to leak out of them into the alveolar spaces.

When taking a history from a patient exposed to fire or toxic inhalants, gather the following information:

- The nature of the inhalant or the combusted material. Many irritant gases combine with water to form corrosive acids or alkalies that cause burns of the upper respiratory tract. Such gases include ammonia (forms ammonium hydroxide when combined with water), nitrogen oxide (forms nitric acid), sulfur dioxide (forms sulfurous acid), and sulfur trioxide (forms sulfuric acid). In addition, victims of fire may inhale another highly toxic gas, phosgene, which is formed by the composition of chlorinated hydrocarbons at high temperatures.
- The duration of the exposure.
- Whether or not the patient was in a closed area when the exposure took place. As a general rule, victims trapped in closed areas with smoke or fumes are more likely to sustain respiratory tract injury, although smoke or fumes in open areas can also result in damage.
- Whether or not the patient lost consciousness. Reflex mechanisms that ordinarily protect the lower respiratory tract may have been impaired if the patient has been unconscious.

During the physical examination, pay careful attention to the face and mouth, inspecting them for burns, and to auscultation of the chest, listening carefully for rales and wheezes. Examine the patient's throat.

When treating patients who have inhaled toxic substances:

- Establish and maintain an airway. Rapidly developing laryngeal edema may require early endotracheal intubation or cricothyroidotomy in the field. Assist ventilations as needed.
- Administer $O_2$ in the highest concentration available to all patients removed from the area of a fire or other sources of toxic inhalants.
- Establish an IV line with Ringer's lactate or saline.

## Pulmonary Embolism

Adequate gas exchange in the lungs requires (1) functional alveoli to provide $O_2$ and take up $CO_2$ and (2) intact pulmonary blood vessels to carry the blood to the alveoli for gas exchange. Some abnormalities that can interfere with alveolar function have already been discussed. But even normal alveoli are of little use if the venous blood cannot reach them. This occurs in pulmonary embolism.

Pulmonary embolism is the sudden blocking of a pulmonary artery or one of its branches by a clot or other small particle carried by the blood. Pulmonary emboli arise from different sources. Blood clots that form in the veins of the legs or pelvis may break loose and be moved by the venous circulation through the right heart, becoming impacted in the progressively narrowing network of pulmonary vessels. Factors favoring the development of such emboli include:

- Prolonged immobilization, as bedridden patients experience. Long periods of physical inactivity cause the blood to become stagnant in the lower extremities. Immobilization of a lower extremity in a cast has a similar effect.
- Thrombophlebitis, or inflammation of the veins, especially those in the legs and pelvis. Patients with thrombophlebitis in the leg sometimes complain of calf pain, and the calf may be tender to palpation.
- Use of certain drugs—notably oral contraceptives.

The symptoms and signs of pulmonary embolism depend on the size of the obstruction. If a large clot lodges in a pulmonary vessel, gas exchange will be severely impaired, and the patient will show signs of respiratory distress. Thus, the right heart will have to work harder to push blood into the clogged pulmonary arteries, and the signs of right heart failure may also develop.

The typical patient with pulmonary embolism experiences the sudden onset of severe unexplained dyspnea. There may be no other symptoms, or the patient may also have sharp chest pain made worse by coughing and deep breathing.

On physical examination, the patient may be laboring to breathe and will almost always show evidence of tachycardia. The patient's blood pressure may be falling. If right heart failure accompanies the pulmonary embolism, the jugular veins will be distended. There may be no abnormalities found in the examination of the chest. Occasionally, the source of the embolus is evident in a tender, swollen calf, but usually the source cannot be found.

Treatment in the field is largly supportive, since definitive therapy requires hospitalization. To treat pulmonary embolism in the field:

- Establish an airway.
- Assist in ventilations as needed.
- Administer $O_2$ in the highest possible concentration.
- Establish an IV route with D5W.
- Monitor cardiac rhythm.

**Table 5.2.—Differential Diagnosis of Dyspnea**

| | Pulmonary Edema | COPD | Spontaneous Pneumothorax | Pulmonary Emboli | Asthma |
|---|---|---|---|---|---|
| Possible history.. | Diagnosis of acute myocardial infarction; use of "water pills"; sudden weight gain; cough; watery sputum; orthopnea. | Emphysema; bronchitis; heavy smoking; recent cold; chronic dyspnea; use of "breathing pills" or inhalers. | Sudden, sharp, chest pain; sudden dyspnea, brought on by strenuous exercise, cough, air travel; patient often tall, thin, young male or COPD patient. | Sudden, sharp chest pain; sudden dyspnea; prolonged immobilization; recent surgery or trauma to lower extremities; thrombophlebitis; sickle cell anemia; use of oral contraceptives. | Acute episodic dyspnea; young patient; allergies relieved by shots in the past; cold or flu preceding attack. |
| Possible physical findings. | Distended neck veins; rales; $S_3$ gallop. | Increased anterior-posterior diameter of chest; purse-lip breathing; wheezing; rhonchi; prolonged expiratory phase of respiration; use of accessory muscles to breathe. | Decreased breath sounds and decreased resonance on side of collapsed lung; tracheal deviation. | Tachypnea; tachycardia; hypotension; pleural rub; phlebitis in legs. | Wheezing: hyperresonance; if bronchospasm severe, chest may be silent. |
| Treatment in the field. | *Oxygen;* monitor IV with D5W to keep open; physician may order morphine, furosemide. | *Oxygen*—but watch for depression of breathing; be prepared to ventilate; monitor IV with D5W to keep open; physician may order aminophylline. | *Oxygen*; monitor; IV at discretion of physician. | *Oxygen*; monitor; IV with D5W to keep open. | *Oxygen*; monitor; epinephrine SC; physician may order aminophylline; IV with D5W (for hydration). |

## Hyperventilation Syndrome

A syndrome caused by hyperventilation can occur in anxious patients. Patients who are prone to hyperventilation may have a history of other symptoms characteristic of anxiety such as fatigue, nervousness, dizziness, and tingling or numbness around the mouth and in the hands and feet. On physical examination, these patients will show rapid respirations (tachypnea) and sometimes unusually deep respirations (hyperpnea). Patients may also show carpopedal spasm—the contortion in a flexed position of the hands and feet. Patients who are predisposed to seizures are especially likely to experience them during a hyperventilation episode.

Hyperventilation leads to a fall in arterial $PCO_2$, which can in turn cause significant electrolyte imbalances leading to respiratory alkalosis. If hyperventilation is your diagnosis, have patient breathe in and out of a paper bag or similar device that will cover the nose and mouth. This causes the patient to rebreathe $CO_2$, thus restoring arterial $PCO_2$ to normal.

Dyspnea will be the presenting complaint in many situations. Choose carefully among the different alternatives when determining the cause of this symptom. Table 5.2 illustrates some factors to be considered when diagnosing dyspnea.

Whatever the source of respiratory insufficiency, there are certain general principles of management that apply:

- The airway always receives first priority. In trauma victims who may have associated cervical spine injuries, the airway should be protected without extending the neck.
- Any patient in respiratory distress should receive $O_2$.
- Any patient whose illness or injury suggests the possibility of hypoxia should receive $O_2$.
- If there is a question whether $O_2$ should be administered or withheld (as in hypoxia), administer $O_2$. Know which patients will respond to $O_2$ therapy with respiratory depression and be prepared to assist ventilation. Never withhold $O_2$ therapy from a patient suspected of hypoxia.

# Unit 4. Techniques of Management

## Oxygen Administration

Oxygen ($O_2$) is a colorless, odorless gas, normally present in the atmosphere in approximately a 21 percent concentration (158 torr at sea level). Pure or 100-percent oxygen is obtained commercially by fractional distillation, a process in which air is liquefied and the gases other than oxygen (primarily nitrogen) are boiled off. The resulting liquid oxygen is then converted under high pressure to a gas and stored in steel cylinders. These cylinders, under pressure of about 2,000 pounds per square inch (psi), are given letter designations according to size. For example, an "E" cylinder is about 4.5 inches in diameter and 30 inches in height; a "G" cylinder, about 8.5 inches in diameter and 55 inches in height.

Gas flow from an oxygen cylinder is controlled by a regulator that reduces the cylinder's high gas pressure to a safe range (around 50 psi) and controls the flow from 1 to 15 liters per minute (l/minute). These regulators are attached to the cylinder by a yoke, which is designed so that its pins will fit only one type of gas cylinder. All gas cylinders are color coded by contents; in this country, oxygen cylinders are always green.

Some safety precautions are necessary when handling oxygen cylinders:

- Keep combustible materials, like oil or grease, away from the cylinders or the cylinder regulators, fittings, valves, or hoses.
- Do not smoke in any area where oxygen cylinders are in use or are being stored.
- Do not subject the oxygen cylinders to temperatures of above 120° F.
- Do not use the oxygen cylinders without safe, properly fitted regulator valves. Never modify regulator valves for a specific gas for use with another gas.
- Close all valves when oxygen cylinders are not in use, even if they are empty.
- Secure the oxygen cylinders to prevent them from toppling over. In transit, keep them in a proper carrier or rack or strap them onto the stretcher with the patient.
- When working with an oxygen cylinder, always keep to its side. Never place any part of your body over cylinder valves. Loosely fitting regulators can be launched off the cylinders with enough force to decapitate a victim or demolish any object in its path.

Keeping these precautions in mind, administer oxygen by following these steps:

- Secure the cylinder in an upright position and move to one side of the cylinder.
- With the wrench supplied, "crack" the tank—slowly open and quickly close the cylinder to flush out any debris.
- Inspect the regulator valve to be certain that it is the right type for an oxygen cylinder and that its washer is intact.
- Apply and tighten securely the regulator valve.
- Open the main cylinder valve slowly to about one-half a turn beyond the point where the regulator valve becomes pressurized.
- Open the control valve to the desired liter flow rate.

To stop oxygen administration:

- Shut off the control valve until the flow rate is zero.
- Shut off the main cylinder valve.
- Bleed the valves by opening the control valve until the needle or ball indicator turns to zero flow.
- Close the control valve.

Each day open the main cylinder valve on the oxygen tank carried in your vehicle and check its remaining pressure. You do not want to come to the aid of a gasping patient with flashing lights and sirens only to discover that the oxygen cylinder is empty. Check cylinders frequently and replace them when pressure is low. If possible, carry a backup cylinder in the vehicle.

To determine about how long an oxygen cylinder will last, divide its liter capacity by the flow rate used. For example, a "G" cylinder has a flow of 8 liters per minute, thus:

$$\frac{6{,}370\ 1}{8\ \ 1/\text{minute}} = 795 \text{ minutes}$$

$$\frac{795 \text{ minutes}}{60 \text{ minutes per hour}} = 13 \text{ hours } 15 \text{ minutes}$$

Therefore, a "G" cylinder should last about 13¼ hours at a flow rate of 8 liters per minute. Sizes and capacities of oxygen cylinders are shown in Table 5.3.

Different masks and cannulas are available to provide supplemental oxygen to the spontaneously breathing patient. Familiarize yourself with the different devices. The characteristics of each are summarized in Table 5.4.

Nasal catheters are soft rubber or plastic tubes with multiple holes at one end. At a 6- to 8-liter-per-minute flow rate, the nasal catheter delivers oxygen concentrations of 30 to 50 percent. Higher rates will irritate the nasal and pharyngeal mucosa. The nasal catheter should not be used in comatose, debilitated, or elderly patients, whose impaired reflexes may permit large amounts of gas to flow into the stomach, resulting in gastric distention. Follow these steps when inserting the nasal catheter:

- Explain to the patient what is about to happen.
- Measure the distance from the tip of the patient's nose to the ear lobe and mark off this distance on the catheter.
- Lubricate the end of the catheter with a water-soluble jelly.
- Gently insert the catheter into one nostril until the tip of it is visible in the pharynx, just behind the uvula; try the other nostril if resistance is encountered.
- Withdraw the catheter slightly, until the tip can no longer be seen in the back of the throat.
- Tape the catheter securely to the patient's nose and cheek.
- Turn the oxygen flow on, and adjust to the desired setting.

Never advance the catheter beyond the flow mark. If advanced too far, the catheter may enter the esophagus and cause severe gastric distention.

Nasal cannulas (prongs) are made of plastic tubing and have two plastic tips that are inserted into the nostrils. They will deliver an oxygen concentration of 25 to 40 percent with a 4- to 6-liter-per-minute flow. Nasal prongs are usually well-tolerated, but can cause soreness around the nostrils. Nasal cannulas deliver a limited maximum oxygen concentration.

Simple plastic face masks can deliver up to 60-percent oxygen, depending on the oxygen flow rate and the patient's tidal volume. Exhaled air is vented through holes in each side of the mask. At low oxygen flow rates and high tidal volumes, the patient may draw in more room air through the side holes, thus diluting the oxygen concentration received. Generally, a flow rate between 8 and 12 liters per minute will ensure adequate oxygen delivery.

Venturi masks are designed to mix oxygen with air, thereby permitting delivery of accurate, low oxygen concentrations. Masks are available to deliver 24 percent, 28 percent, 35 percent, and 40 percent oxygen.

**Table 5.3.—Oxygen Cylinder Sizes and Capacities**

| Letter | Height (inches) | Diameter (inches) | Weight (pounds) | Capacity (liters) |
|---|---|---|---|---|
| A | 103¾ | 3 | | 90 |
| B | 16½ | 3¼ | 5¾ | 180 |
| D | 20¼ | 4¼ | 10¼ | 430 |
| E | 29¾ | 4¼ | | 750 |
| M | 47 | 7 | 66 | 3,640 |
| G | 55 | 8½ | 100 | 6,370 |
| H | 56 | 9 | 135 | 8,305 |

They are especially useful in the hospital management of patients with chronic obstructive pulmonary disease and $CO_2$ retention, but offer no advantage in the field, except when transporting such patients over long distances.

Face tents (hoods) primarily are suited for hospital use. They effectively deliver high humidity through an attached heated nubulizer or ultrasonic device. With flow rates of between 4 and 8 liters per minute, hoods will deliver oxygen concentrations of 30 to 50 percent.

Partial rebreathing masks look like plastic face masks but have reservoir bags that allow the patient to rebreathe about one-third of the air expired. This air comes principally from areas of the patient's respiratory tract where gas exchange does not take place (the dead space). Therefore, it contains mostly oxygen inspired during the previous cycle. At flow rates of 6 to 10 liters per minute, partial rebreathing masks can provide oxygen concentrations of 35 to 60 percent.

Nonrebreathing masks are similar to partial rebreathing masks in that they have an oxygen reservoir. But they are also equipped with a one-way valve to allow inhalation of oxygen from the reservoir bag and exhalation through the valve. The oxygen flow rate is adjusted to prevent collapse of the bag during inspiration. The resulting flow rate is usually about 10 to 12 liters per minute. If the mask is fitted tightly to the face, it can deliver $O_2$ concentrations approaching 100 percent. Therefore, it is well suited to situations where there is severe hypoxia.

In general, plastic face masks or nonrebreathing masks are preferred in the field because they deliver higher oxygen concentrations. Some patients, however, can barely tolerate the masks and complain of suffocation. For such patients, the nasal cannula may be used. No matter what device you choose, explain to the patient its function and why it is needed. Let the patient know that the mask may feel confining but that it actually provides more air than unaided breathing. Such an explanation may help the patient accept the mask without anxiety.

## Adjunctive Equipment

Before using adjunctive equipment to maintain an airway, first position the patient's head and jaw so that unobstructed ventilation is possible. There are several ways to accomplish this. One of the simplest maneuvers is the head tilt-neck lift. Place one hand beneath the patient's neck and the other on the forehead, then lift the neck with one hand and tilt the head backward by pressing on the forehead with the other (Figure 5.7). This maneuver lifts the patient's tongue from the back of the throat.

An alternative and equally effective technique for opening the airway is the head tilt-chin lift. Place the tips of the fingers of one hand under the patient's lower jaw near the chin and bring the chin forward. With the other hand press on the patient's forehead and tilt the head backward. Lift the chin so that the teeth are nearly brought together, but do not close the mouth completely. Do not compress the soft tis-

**Table 5.4.—Types of Masks and Cannulas for Providing Supplemental Oxygen**

| Device | Flow Rate Used (liters per minute) | $O_2$ Concentrations Delivered (percentage) | Comment |
|---|---|---|---|
| Nasal catheter | 6–8 | 30–50 | Do not use in comatose patient. |
| Nasal cannula | 4–6 | 25–40 | Usually well-tolerated. |
| Plastic face mask. | 10 | 50–60 | |
| Venturi mask | | | |
| 24 percent | 4 | 24 | Long-term treatment of patients with COPD; limited usefulness in the field. |
| 28 percent | 8 | 28 | |
| 35 percent | 8 | 35 | |
| 40 percent | 8 | 40 | |
| Face tent | 4–8 | 30–50 | High humidity; limited usefulness in the field. |
| Partial rebreathing mask. | 6–10 | 35–60 | |
| Nonrebreathing mask. | 10–12 | 90 | Permits administration of high concentration of $O_2$. |

sues under the chin, for this might obstruct the patient's airway.

This technique is illustrated in Figure 5.8.

If a patient is capable of spontaneous ventilation, no further manipulation of the airway may be needed. If, however, any airway cannot easily be maintained by positioning of the head and jaw, especially in the comatose or arrested patient, adjunctive equipment may be useful. But remember that even with adjunctive equipment, proper placement of the patient's head must be maintained.

The oropharyngeal and nasopharyngeal airways are the two types of airways most commonly used. Each is designed for use in different situations.

The oropharyngeal airway is a curved device that fits over the back of the tongue and holds it away from the posterior wall of the throat. This device is inserted upside down (tip upward) into the mouth and then rotated as the tip reaches the back of the tongue. Do not push the tongue backward into the throat while inserting the oropharyngeal airway (Figure 5.9). Do not use the oropharyngeal airway on a conscious patient. It can stimulate gagging and vomiting in a person with functioning reflexes.

The nasopharyngeal airway is a soft rubber tube, which is inserted through the nose into the pharynx behind the tongue, thus allowing air to pass from the nose to the lower airway. (Hard, plastic nasopharyngeal airways are unnecessarily traumatic and should not be used.) The device should be well lubricated with water-soluble jelly and inserted gently to avoid injury to or bleeding from the nasal passages. Semiconscious patients tolerate this airway more than the oropharyngeal airway.

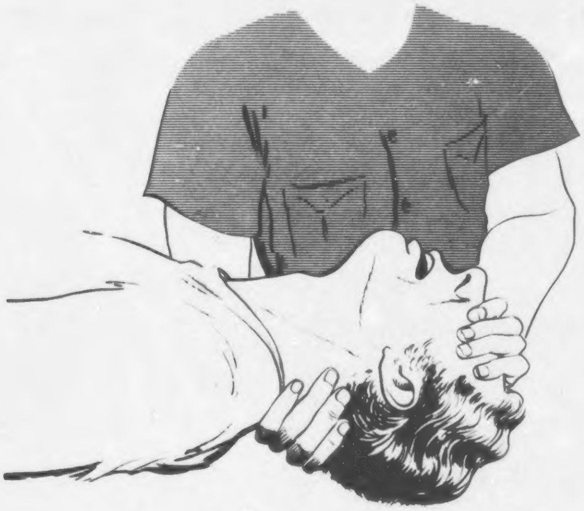


**Figure 7. Head Tilt Method of Opening the Airway**

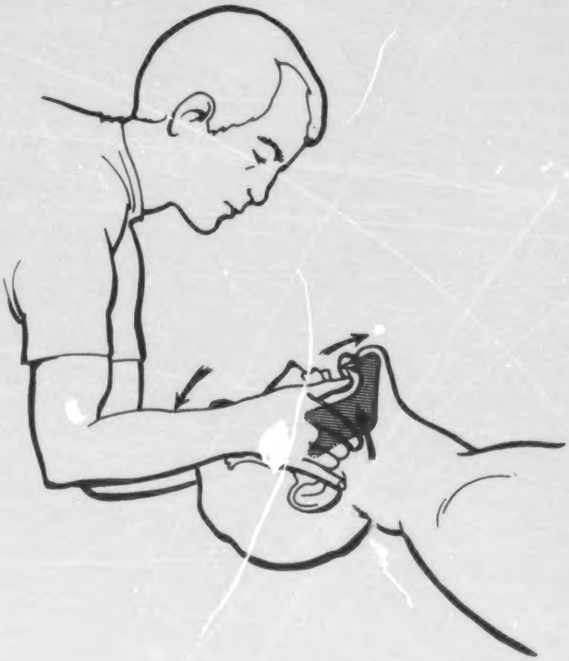


**Figure 8. Triple Airway Maneuver**

Two ventilation devices are used to treat patients requiring artificial respiration: the pocket mask and the bag-valve mask. Know how to use each device.

The pocket mask with an oxygen inlet valve eliminates direct contact with the patient's nose and mouth and permits mouth-to-mouth ventilation with up to 50-percent oxygen, with a flow rate of 10 liters per minute. An oxygen line connects to the mask's inlet valve. To use a pocket mask, open the victim's airway and place the rim of the pocket mask between the patient's lower lip and chin. Retract the lip and hold the mouth open (Fig. 5.10). With both thumbs along the side of the mask, clamp the remainder of the mask to the face. Grasp the jaw just beneath the angles with the fingers while maintaining a backward tilt of the head and a jaw thrust. Then exhale intermittently into the mask, forcing the breath, which is enriched with oxygen, into the patient's lungs. If the oxygen flow rate is high enough (control valve wide open), periodically occlude the opening of the mask with the tongue and allow the oxygen flow to ventilate the patient. This technique will produce an inspired oxygen concentration much higher than 50 percent. As with any other means of artificial ventilation, when using the pocket mask, observe the chest for the rise and fall, which indicates adequate ventilation. Because both hands can be utilized by the rescuer to maintain an open airway, masks of this type are easier to use than bag-valve masks.

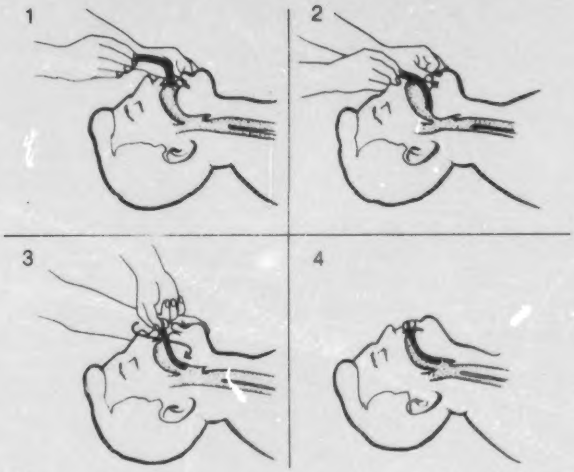


**Figure 9.** **How an Oropharyngeal Airway Is Inserted**

Bag-valve masks are self-inflating and, when used without supplemental oxygen, deliver room air (21-percent oxygen) to the patient. If an oxygen source with a flow rate of 12 liters per minute is attached to the bag-valve mask, the delivered oxygen concentration can be increased to 40 percent. Adding an oxygen reservoir to the bag can further increase the inspired oxygen concentration to about 90 percent.

The mask used by a bag-valve device should be transparent so that vomitus or secretions around the patient's mouth can be seen. To correctly employ the bag-valve mask:

- Apply the mask so that it fits snugly over the patient's chin, beneath the patient's lower lip, and over the bridge of the patient's nose (Figure 5.11).
- Place thumb and index finger on the mask—thumb above the index finger and below the valve connection—and use the other fingers to grip the patient's mandible and form a tight seal.
- Tilt the patient's head back to open the airway and compress the bag with the other hand.

Watch for the rise and fall of the chest to be certain that ventilation is occurring. Often, an oropharyngeal or nasopharyngeal airway is desirable to keep the airway open.

The bag-valve mask is more convenient and delivers a more enriched oxygen mixture than mouth-to-mouth ventilation. Keep in mind, however, that the bag-valve mask rarely generates the tidal volumes possible with mouth-to-mouth ventilation. Gastric distention is a problem with both techniques.

Bag-valve masks with oxygen supplementation may be used to assist the ventilations of a spontaneously breathing patient. Apply the mask to the patient's face in the manner described above, and gently squeeze the bag as the patient takes a breath.

## Demand Valve

Manually triggered ventilation devices, or demand valves, are available in many ambulances and are acceptable for emergency use if they deliver a flow rate of at least 100 liters per minute. These devices may be connected to a mask, an endotracheal tube, or an esophageal obturator airway and are used most appropriately to assist ventilation in a spontaneously breathing patient. A slight negative pressure, produced by the patient's inspiratory effort, will trigger the $O_2$ flow. The flow continues until the negative pressure ceases and exhaled gases exit through a nonbreathing valve.

When treating an apneic patient, do not use an oxygen-powered breathing device for very long with a mask, because it may cause severe gastric distention. Do not use the device at all on patients under 12 years of age, except under very special circumstances (i.e., airway obstruction due to croup or epiglottitis). Because demand valves may develop high pressures, the use of such a device with an endotracheal tube must be undertaken with caution. Bag-valve masks provide finer control of ventilation and better assessment of the patient's lung compliance.

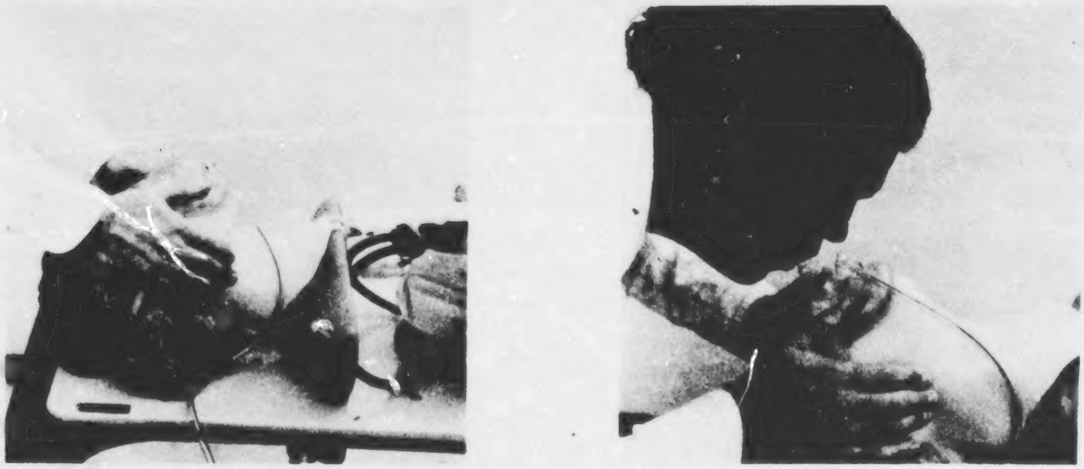
## Suctioning

Suctioning of the mouth and throat is most easily performed with a rigid, tonsil tip catheter. Because it is easily directed to the desired location, this device is particularly useful in clearing secretions that obstruct vision during intubation. Do not jam the tonsil tip catheter blindly into the patient's mouth or throat; make sure you can see where you are directing it. Between suctioning attempts, clear the catheter in sterile water or saline and oxygenate the patient. The suction unit should deliver at least 30 liters per minute air flow at the end of the tube.

### Tracheal suctioning: the nonintubated patient.

To clear large amounts of secretions from the patient's airway, tracheal suctioning may be necessary. Suctioning should always be performed with sterile techniques to avoid introducing bacteria into the patient's lower respiratory tract. The patient must always be preoxygenated, and suctioning should not continue for more than 10 seconds at a time. Place all patients undergoing tracheal suction on a cardiac monitor. To accomplish tracheal suction:

- Place the patient in a semisitting position. Allow the patient to breathe 100 percent $O_2$ for at least 3 minutes.
- Put on sterile gloves and prepare a sterile field for the catheter and rinse (sterile saline).



Pocket Mask

**Figure 10. Use of a Pocket**

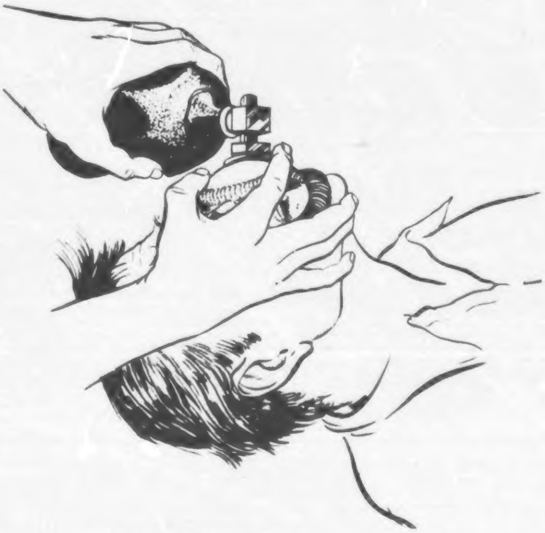
- Insert the sterile catheter through a nostril into the pharynx. (The suction should not be engaged yet.) This will probably cause the patient to gag.
- Ask the patient to cough or take slow deep breaths while advancing the catheter. This should allow the catheter to pass beyond the vocal cords.
- Continue gently advancing the catheter as far as possible; then withdraw it, applying intermittent suctioning and rotating the catheter as it is pulled out. Do not apply suction for more than 10 seconds.
- Rinse the catheter. If the tracheal suctioning is not to be repeated, suction around the patient's mouth at this time.
- If suction is repeated, preoxygenate the patient for at least 3 minutes before repeat suctioning. Once a catheter has been used to suction the mouth, it should not be advanced into the trachea again; use a fresh catheter.
- When suctioning is complete, discard gloves, catheter, and any other contaminated materials.

### Tracheal suctioning: the intubated patient.

When large amounts of secretions interfere with adequate ventilation, suctioning through an endotracheal tube is indicated. This process is not without danger—cardiac arrest has been reported during tracheal suctioning—and should not be done unnecessarily.

Use a suction catheter with a side thumb vent or Y tube to permit intermittent suction. The external diameter of the catheter should be no greater than one-third the internal diameter of the endotracheal tube. A 14- or 16-gauge French catheter is suitable for most adult patients. To accomplish tracheal suction in an intubated patient:

- Connect the patient to a cardiac monitor.
- Preoxygenate the patient by bagging for 3 minutes with 100 percent oxygen, using a bag-valve mask with a reservoir and a 12-liter-per-minute oxygen flow.
- Assemble equipment and put on sterile gloves.
- Introduce the catheter gently into the endotracheal tube, being careful not to let the catheter touch the outside of the tube.
- Advance the catheter as far as possible before starting suction.



The Bag-Valve-Mask

**Figure 11. The Correct use of a Bag-Valve-Mask**

- Apply intermittent suction as the catheter is withdrawn, rotating it as it is withdrawn. Do not take more than 10 seconds. Remember, prolonged suctioning can cause hypoxia and cardiac arrest! Keep an eye on the monitor. Discontinue suctioning and administer oxygen to the patient at the first sign of an arrhythmia.
- Before repeating the procedure, reoxygenate the patient with 100 percent oxygen for at least 3 minutes.
- After suctioning the tracheobronchial tree, flush the catheter with sterile saline. The nasopharynx and mouth may then be suctioned with the same catheter, but once the catheter has been used in the nose, mouth, or throat, do not use it in the endotracheal tube.
- Should cardiac arrhythmias, bronchospasm, or other problems arise, stop suctioning immediately, withdraw the catheter, and administer 100-percent oxygen to the patient.

## Direct Laryngoscopy

Direct laryngoscopy is an examination of the larynx and associated structures with a laryngoscope. Usually, it is performed to locate and remove a foreign body obstructing the airway (e.g., in the "cafe coronary"). It is also part of the procedure for endotracheal intubation.

Within the handle of the laryngoscope is a battery and a removable blade. There are two basic types of blades—curved (Macintosh) and straight (Miller, Guedel). The curved blade is designed to slip between the epiglottis and the base of the tongue, while the straight blade is designed to expose the vocal cords by lifting the epiglottis. Check the laryngoscope periodically and always before each use to ensure that the batteries and light bulb are functioning. The light should be bright white and steady; a flickering yellow light is useless. Assemble the laryngoscope and check the light on each blade every day. Replace aging batteries or bulbs promptly.

The Magill forceps is a long, curved device designed to reach into the posterior pharynx. It is used to extract foreign bodies visible during direct laryngoscopy and, also, to guide an endotracheal tube into place during nasotracheal intubation.

In most cases involving foreign body obstruction—in the "cafe coronary," for example—you will not have time to make elaborate preparations. Speed is important. To perform direct laryngoscopy:

- Assemble the laryngoscope and have the Magill forceps handy.
- Flex the patient's neck forward and extend the head backward so that the head is in the "sniffing" position.
- Grasp the laryngoscope in the left hand and the Magill forceps in the right. Insert the laryngscope blade into the right side of the patient's mouth and gently use the blade to push the patient's tongue toward the left.
- Slowly advance the blade toward the epiglottis, exerting gentle traction upward at a 45 degree angle, until the foreign body is clearly visible.
- Grasp the foreign body securely with the Magill forceps and pull it free. As soon as the obstructing object is removed, withdraw the laryngoscope blade and attempt to ventilate the patient. Inability to ventilate with the head properly positioned may indicate part of the object is still in the airway. Look again. Time is critical.
- Be sure that an oxygen cylinder and bag-valve mask are available while removing the object so that ventilation with an enriched oxygen mixture can begin immediately after the object is removed.

Figure 5.12 illustrates the correct position of the patient and the laryngoscope for removing a foreign body from the airway.

## Endotracheal Intubation

Endotracheal intubation is the best way to achieve complete control of the airway, offering several advantages over other adjunctive or nonadjunctive techniques:

- It employes the cuffed endotracheal tube that protects the airway from aspiration.
- It permits IPPV with 100 percent oxygen.
- It provides access to the tracheobronchial tree for suctioning of secretions.

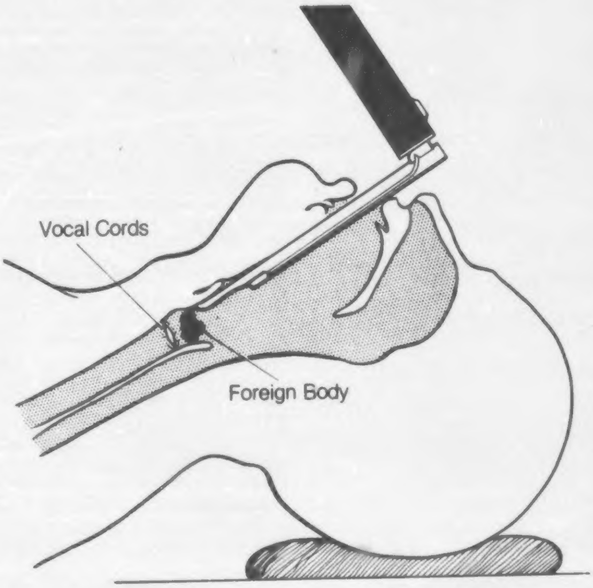


**Figure 12.** **The Correct Position of the Patient and Visualizing a Foreign Body with a Laryngoscope**

- It does not cause the gastric distention associated with mouth-to-mouth or bag-valve mask ventilation.
- It maintains a patent airway in patients who develop obstruction despite the use of oropharyngeal or nasopharyngeal airways.

The principal immediate hazards of the technique are inadvertent intubation of the esophagus and passage of the endotracheal tube past the carina into the right mainstem bronchus. Proper technique, including careful auscultation of all lung fields after intubation to be sure that breath sounds are heard equally on both sides of the chest, reduce the chances of either hazard occurring. Additional immediate complications of attempted intubation include injury to teeth, lips, mouth, pharynx, or larynx; bronchospasm; and aspiration of blood or vomitus during the intubation procedure.

Endotracheal intubation should not be attempted until the patient has been adequately oxygenated by some other means (mouth-to-mouth ventilation, bag-valve mask, bag-esophogeal obturator, etc.). One of the most common mistakes in the treatment of cardiac arrest is attempting endotracheal intubation too early, thus wasting precious time in an already hypoxic patient. The patient needs the period of oxygenation before intubation to tolerate the 20 to 30 seconds without ventilation that occurs during insertion of the endotracheal tube.

While another member of the team manages the airway and ventilation, carefully assemble the following equipment:

- **Endotracheal tube**. Choose an endotracheal tube of the appropriate size. (A size 8-mm internal diameter tube is probably most easily passed in an average adult.) The cuff should be inflated to check for leaks and then deflated; a syringe should remain attached. Keep a hemostat ready to clamp off the inflation line. Lubricate the end of the endotracheal tube with water-soluble jelly. A stylette may be placed inside the tube to stiffen its curve. If one is used, it should be lubricated to facilitate removal. In addition, bend its terminal end to form a gentle "hockey stick" curve. The end of the stylette should rest at least one-half an inch back from the end of the endotracheal tube. Insertion of the stylette beyond the end of the endotracheal tube may damage the vocal cords and the surrounding structures.
- **Laryngoscope blade**. Assemble the laryngoscope and check the light to make sure it is white and steady. An alternate type blade (its light also checked) should be available if needed.
- **Suction apparatus**. Check the suction apparatus. Attach a tonsil suction catheter to the tubing. Place the suction apparatus within easy reach.
- **Bite block or oropharyngeal airway**. Prepare a bite block or oropharyngeal airway for insertion after intubation. Either of these devices prevents the patient from biting down on the tube.

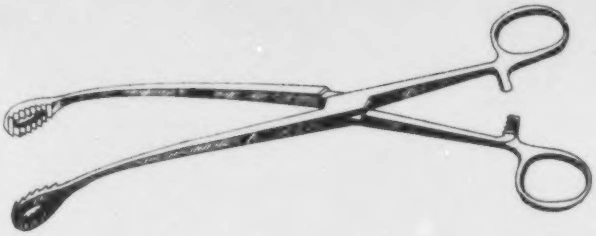


**Figure 13. Removing a Foreign Body with Magill Forceps**

- **Tape**. Prepare tape strips of the appropriate length to secure the endotracheal tube in place.
- **Magill forceps**. Keep a Magill forceps on hand in case a foreign body obstructing the airway needs removal (see Figure 5.13).

While one rescuer is preparing the equipment, another should:

- Hyperventilate the patient with 100 percent oxygen. Partial plates and dentures should be removed before intubation is attempted.
- Flex the patient's neck forward and extend the head backward so that the head is in the "sniffing" position. It may help to put a folded towel under the patient's shoulders and another under the head.
- Grasp the laryngoscope in the left hand and insert the blade into the patient's mouth; insert the blade into the right side of the mouth and then use it to push the tongue gently to the left.
- Advance the blade—the curved blade to the vallecula (the space between the epiglottis and the base of the tongue) or the straight blade beneath the epiglottis. Exert gentle traction upward at a 45° angle to the floor. Do not use the upper teeth as a fulcrum.
- Advance the blade until the epiglottis and vocal cords come into view (see Figure 5.14).
- Suction out any secretions that are in the way.
- Under direct vision, insert the tube with the right hand, from the right corner of the mouth, and pass it through the vocal cords.
- Remove the stylette from the tube after the cuff passes about 1 inch (not more) beyond the vocal cords.
- Observe the chest to see whether it rises with ventilation, and auscultate both sides to determine whether breath sounds are equal.
- Inflate the cuff, clamp off the inflation line beyond the small pilot balloon, and ventilate through the tube (see Figure 5.15).
- Secure the tube if it is properly positioned. Never take the hand off the endotracheal tube before it

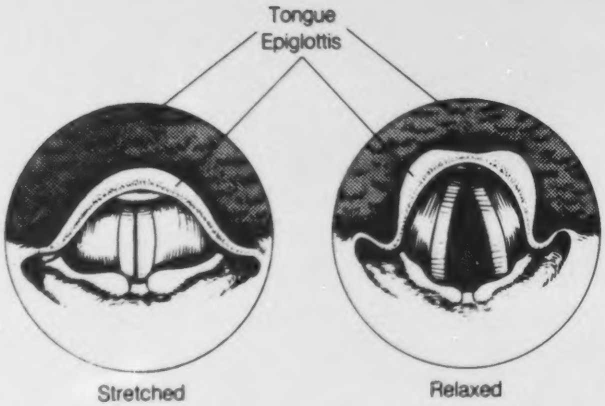


**Figure 14. View of the Vocal Cords Through the Laryngoscope**

has been secured with tape or ties. Even then, it is a good idea to support the tube by hand. There is nothing more discouraging than to accomplish a difficult intubation only to have the tube slip out of the trachea.

If breath sounds are absent when ventilating through the tube, the esophagus is probably intubated. Deflate the cuff immediately, remove the tube, and ventilate the patient before the next attempt. If breath sounds are heard on only one side of the chest (usually the right) or are much louder on one side, the tube has probably entered a mainstem bronchus. In this case, deflate the cuff and pull the tube back very slowly. At the same time, ventilate the patient until breath sounds are heard equally on both sides of the chest. Then, reinflate the cuff, and secure the tube in place.

A word of caution: *An intubation attempt should not take any more than 30 seconds.* The most frequent and serious complications result from protracted periods of interrupted ventilation. And, if an endotracheal tube cannot be inserted after two, or at the most, three attempts, ventilation should be performed with an esophageal airway.

Following intubation, oxygenate the patient thoroughly with the bag-valve mask and suction if necessary. Clearly mark the point where the endotracheal tube emerges from the mouth to allow medical personnel to determine whether the tube has slipped in or out. Once the cuff is inflated and the tube secured, a nasogastric tube may be passed, to decompress the stomach, if needed.

## Esophageal Obturator Airway

The esophageal obturator airway is a long tube that superficially resembles an endotracheal tube. It is open at the top, sealed at the bottom, and contains numerous holes on the side near its upper end. A mask fits over the tube at its upper end, and an inflated cuff is located near its bottom end. When the esophageal airway is properly placed and the mask seated firmly on the face, air that is blown in by mouth or bag-valve mask will enter the patient's pharynx through the side holes in the obturator. Since the inflated cuff obstructs the esophagus, and the mask seals off the mouth and nose, air can only travel into the trachea. Thus, the esophageal obturator prevents progressive gastric distention during assisted ventilation and also lessens the liklihood of regurgitation of stomach contents. Using the esophageal airway, however, is not without hazards: Rough handling during insertion may damage structures in the pharynx, and excess inflation of the cuff may rupture the esophagus.

To insert the airway, place its top end through the port of the supplied face mask. Many of these masks have inflatable rims, which should be fully inflated before the airway is inserted. The patient's head should be slightly flexed and the jaw pulled forward while the cuffed end of the tube is advanced blindly, but gently, into the esophagus until the mask sits firmly on the face (see Figure 5.16). If the mouth is dry, the end of the obturator may need to be lubricated with a water-soluble jelly.

Never jam the tube down. If you meet resistance, gently pull the tube back and try to advance it again. In most cases, the tube will follow the natural curvature of the throat and move easily into the esophagus. But because it is always possible to inadvertently intubate the trachea with this device, check the location of the tube: Tilt the patient's head back, hold the mask in place, ventilate through the airway, and watch the chest to see if it rises and falls. If the chest moves, the tube is in the esophagus, and the cuff can be inflated with 20 to 30 ml of air. To recheck the position of the esophageal airway, ventilate the chest again and listen for breath sounds. If there is no chest expansion or if breath sounds are absent, the airway may be lodged in the trachea. If this is the case, remove the airway at once (cuff deflated) and continue ventilation by another method. Try again to reinsert the obturator.

Observe these important guidelines when using the esophageal obturator airway:

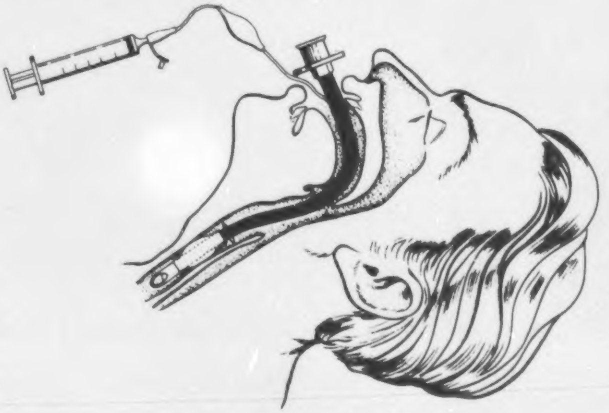


**Figure 15. Inflated Endotracheal Tube in Its Correct Position**

- Use the esophageal airway only on unconscious patients. Its use causes gagging and vomiting on conscious and semiconscious patients.
- Do not use the esophageal airway on patients less than 16 years old or 5 feet tall.
- Do not use the esophageal airway on patients who have esophageal disease, cirrhosis of the liver, or who have ingested caustic substances.
- Do not remove the esophageal obturator airway from an unconscious patient until the airway has been secured with an endotracheal tube. Removal of the esophageal airway results in considerable regurgitation of stomach contents. In this case, unless the trachea has first been protected with a cuffed endotracheal tube, regurgitated material will inevitably enter the lungs.

To intubate the trachea of patient who has an esophageal obturator airway in place:

- Hyperventilate the patient for several minutes with 100 percent oxygen. Have all the equipment ready— suction, laryngoscope, blade, endotracheal tube, syringe, etc.—because once the mask from the esophageal obturator is removed, there will be no way to ventilate the patient. Speed in endotracheal intubation is essential. To remove the mask from the obturator, pinch the tube as it extends through the mask and lift the face mask off.
- Push the obturator tube to the left side of the patient's mouth, insert the laryngoscope blade, and intubate in the usual manner.
- Observe the vocal cords, as you would in any other endotracheal intubation. The presence of an obturator in the esophagus does not guarantee against inadvertent intubation of the esophagus with the endotracheal tube. Look for the cords, which will lie above the esophageal obturator.

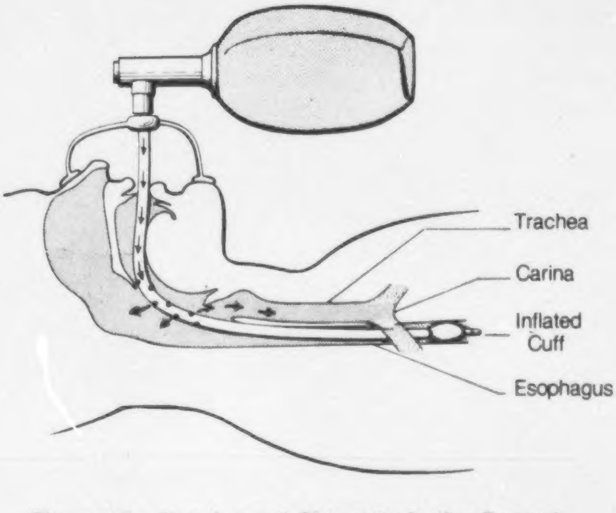


**Figure 16. Esophageal Obturator in the Correct Position**

- Position the endotracheal tube, inflate its cuff, and check the tube's position by auscultating both lung fields. Secure it carefully in place.
- Suction the back of the patient's throat, deflate the cuff on the esophageal obturator, and gently remove the obturator. Keep a tonsil suction handy.
- Anticipate massive regurgitation. No matter how securely the endotracheal tube has been taped or tied in, hold it in place while the obturator is being withdrawn, lest it be pulled out with the obturator.

## Chest Decompression With Catheter and With Catheter and Flutter Valve

In the patient with tension pneumothorax or large simple pneumothorax, emergency decompression of the pleural space may be lifesaving. Be reasonably sure of the diagnosis before attempting this procedure, however, because introducing a needle into the chest will almost certainly create a pneumothorax if the patient does not already have one.

In order to perform this type of chest decompression, assemble the following equipment:

- Large bore (12- to 14-guage), over-the-needle catheter.
- Heimlich valve or a finger cut from a rubber glove.
- Rubber band or suture to secure the flutter valve (or commercially available pneumothorax device).
- Iodine swabs for skin prep.
- Benzoin.
- Dressings, tape.

Insert the catheter into the rubber glove finger, piercing it through the tip (Figure 5.17). To prevent leakage, secure the improvised flutter valve to the catheter with a rubber band or suture. (The flutter valve allows air to escape the pleural space while preventing its entrance. Next, locate the second or third intercostal space (the space between the second and third ribs or between the third and fourth ribs) in the midclavicular line (approximately in line with the nipple) on the affected side on the patient's chest (Figure 5.18) and prep this area thoroughly with iodine. Introduce the catheter and needle, with the flutter device secured over the catheter, just above the rib margin at the site selected. There will be a "pop" as the needle enters the pleural space, and air under pressure should exit through the flutter valve. Advance the catheter over the needle, as you would when starting an IV, and remove the needle. Paint the surrounding skin with benzoin, this will make the tape stick better. Allow the benzoin to dry, and then secure the catheter in place with tape, taking care not

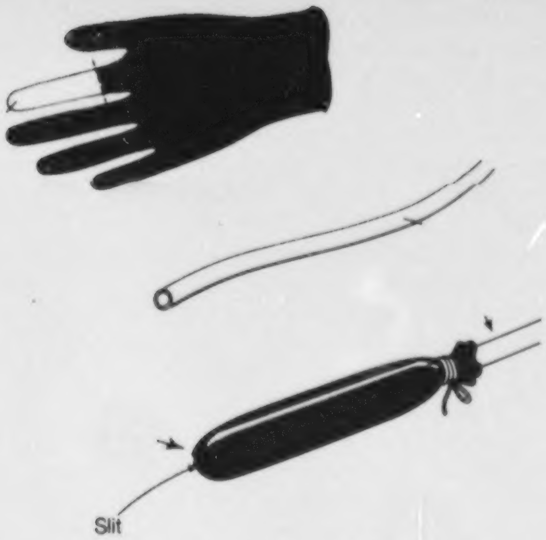


**Figure 17. Preparing a Heimlich Valve Using the Finger of a Rubber Glove**

to let the catheter kink. Make sure the flutter valve, unobstructed, is outside the dressing.

## Use of Positive-End Expiratory Pressure (PEEP)

Positive-end expiratory pressure, or PEEP, is the maintenance of positive pressure at the end of the expiratory phase of respiration. During normal, spontaneous ventilation, the pressure in the airways at the end of expiration is zero, and some alveoli normally collapse during expiration. When widespread atelectasis and shunt are a problem, sometimes it is desirable to maintain positive pressure at the end of expiration to keep alveoli open and drive any fluid present in the alveoli out into the interstitium or capillaries—i.e., severe pulmonary edema, shock lung (adult respiratory distress syndrome), and massive atelectasis from any cause (chest trauma). In the field, PEEP is chiefly indicated for the intubated patient who suffers from one of the above conditions and must be transported a long distance.

There are several ways to create PEEP. In the field, the Biohringer valve—a cylinder enclosing a suspended metal ball—is most useful. When connected to the expiratory port of the bag-valve mask, the valve creates PEEP by forcing the patient to exhale against the weight of the ball. Different valves provide 5-, 10-, and 15-centimeter water expiratory pressure. For the device to function, hold the bag-valve so that the Boehringer valve is at all times vertical. Except for this variation, use standard bag-valve mask ventilation procedure.

## Cricothyrotomy

Cricothyrotomy is indicated to relieve life-threatening upper airway obstruction when manual maneuvers to establish an airway (head tilt, triple airway maneuver) and ventilation attempts have failed and when endotracheal intubation is not feasible. Such cases may include the patient with severe laryngeal trauma or the patient whose upper airway is obstructed by a foreign body that cannot be extracted with direct laryngoscopy.

Cricothyrotomy involves considerable hazard. Possible complications include bleeding into the airway and faulty placement of the cannula in the subcutaneous tissue rather than the trachea, resulting in subcutaneous or mediastinal emphysema. Do not perform cricothyrotomy on infants or children. In all patients, tracheal intubation, when it can be accomplished, is the method of first choice.

One commercially available cricothyrotomy kit consists of a 7-guage stainless steel trocar-cannula and about 22 inches of auxiliary latex rubber tubing for mouth-to-trachea respiration and for administration of oxygen (Figure 5.19). The curvature of the trocar cannula is that of a conventional tracheotomy device so that it lies in the proper plane as it enters the trachea. The bayonet tip of the trocar, which is used to penetrate the cricothyroid membrane, is accurately

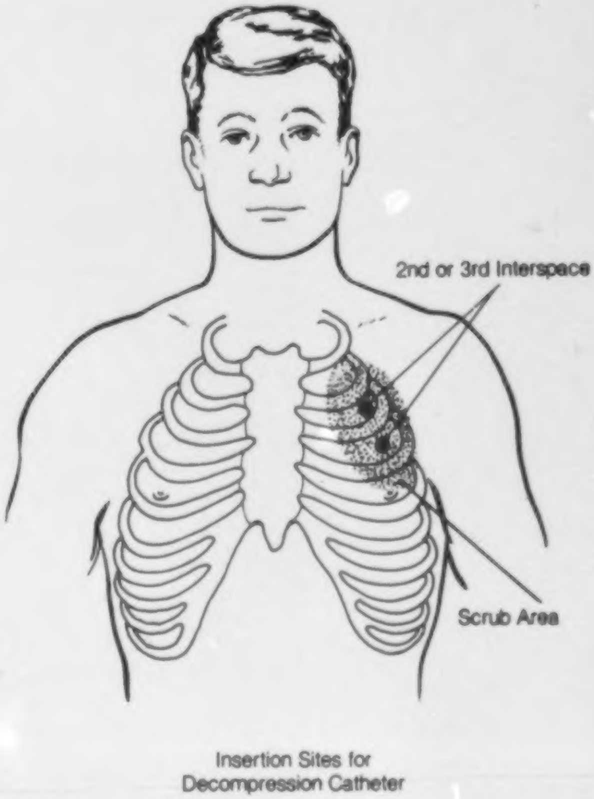


**Figure 18. The Thorax Being Prepared for Insertion of a Decompression Catheter**

tooled to permit smooth penetration of the membrane and insertion of the cannula. The other end of the cannula consists of a notched disk and a Luer-Lok fitting. The auxiliary tubing has a matching Luer-Lok fitting with a chimney projection at one end and a conical piece at the other end shaped to adapt to any source of oxygen. The chimney piece may be fingered rhythmically when the fitting is attached to an oxygen source.

To perform a cricothyrotomy with the above kit:

- Identify the cricothyroid membrane by tilting back the patient's head and palpating for the V-notch of the thyroid cartilage (Adam's apple).
- Stabilize the larynx between the thumb and middle finger, while palpating with the index finger.
- After locating the V-notch, slide the index finger down the depression between the thyroid and cricoid cartilages; this is the cricothyroid membrane (Figure 5.20).
- Puncture the membrane with the trocar-cannula assembly near the fingernail of the index finger along the midline of the membrane and perpendicular to the surface. Insert the cannula until the marker contacts the skin and then remove the trocar.
- Gentle pressure on the cannula will facilitate its entrance into the trachea. Keep the notch of the disk uppermost.
- Affix the disk to the skin with adhesive tape.
- Attach the auxiliary tube and commence mouth-to-trachea respiration or attach to oxygen supply, as indicated. Monitor respiration and modulate oxygen flow by fingering the chimney piece.
- Use a No. 10 catheter for suctioning through the cannula.

Another commercially available kit consists of a knife blade and cannula. The knife blade, mounted in a rubber holder, is short enough to prevent injury to the posterior laryngeal wall. The cannula or emergency airway is a smoothly rounded 90° metal tube. On the outside end, the cannula has a standard 15-millimeter adapter so that it can be attached to such ventilation devices as the bag-valve mask (Figure 5.21).

If a cricothyrotomy kit is not available, any knife blade and a standard 90° tracheostomy tube may be used instead.

When using the kit illustrated in Figure 5.21, first locate the cricothyroid membrane and then:

- Puncture the membrane with the knife blade inserted transversely in the midline along the fingernail. Make the puncture cleanly to avoid later complications.
- While continuing to stabilize the larynx with the left hand, poke the cannula through the puncture hole. Using controlled force, keep the tip pointing toward the feet until the flange is flush with the skin.
- Check for correct cannula location by listening and feeling the airflow through it, and by ventilating through it, while checking whether the chest rises and whether breath sounds are audible.
- Once it is properly positioned, secure the cannula in place with the tape provided.

The technique is potentially hazardous. It should only be performed by persons trained in the animal laboratory and authorized by their physician director to perform this technique in the field.

## Transtracheal Jet Insufflation

Transtracheal jet insufflation is another useful emergency ventilation technique. It utilizes the high-flow,

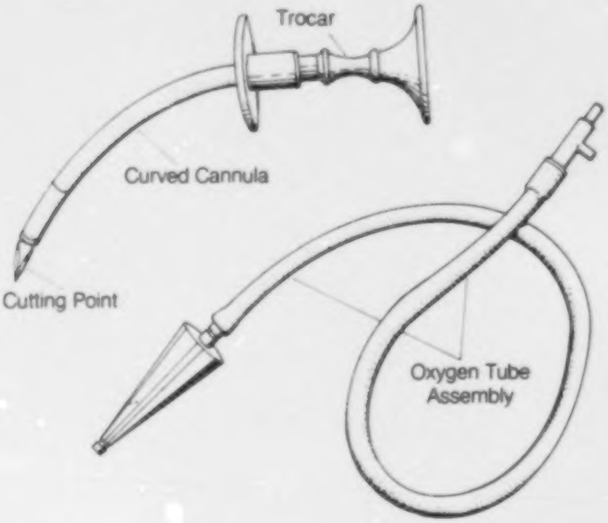


**Figure 19. Cricothyroidotomy Kit**

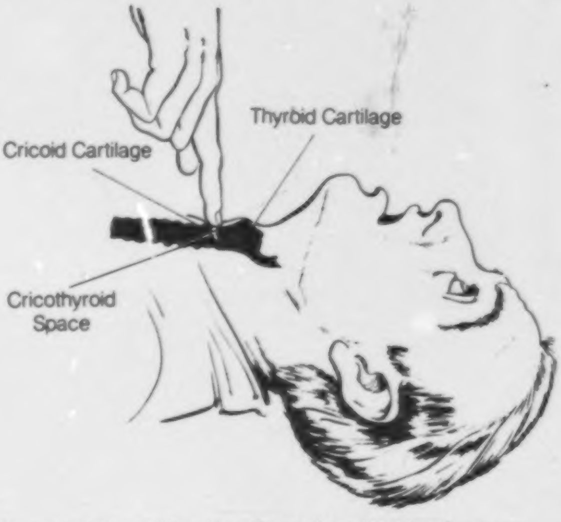


**Figure 20. Locating the Cricothyroid Membrane with the Index Finger**

high-pressure jet principle. Its indications and hazards resemble those of cricothyrotomy, but it requires additional specialized equipment.

To perform transtracheal jet insufflation:

- Place the patient supine and identify the cricothyroid membrane by stabilizing the larynx with the thumb and middle fingers of one hand and palpating for the V-notch (Adam's apple) of the larynx with the index finger. Slide the index finger into the cricothyroid membrane—the groove beneath the V-notch.
- Advance a 14-gauge, over-the-needle catheter, with attached syringe, through the skin and cricothyroid membrane into the trachea at an angle of approximately 60° to the frontal plane (Figure 5.22).
- After popping through into the trachea, aspirate the syringe. If free air returns, the needle is in the correct position.
- Advance the plastic catheter over the needle to its full length, so that the hub rests against the skin, and remove the inner needle (Figure 5.23).
- Aspirate the catheter again to reconfirm its position, and securely fasten its hub to the skin.
- Connect one end of a piece of flexible tubing to the catheter's hub and attach the other end to a hand-operated valve connected to an oxygen source at 60 psi.
- Slowly open the valve to allow gas to flow into the lungs, thus allowing inspiration. Check adequacy of ventilation by observing the chest for expansion and auscultating for breath sounds.

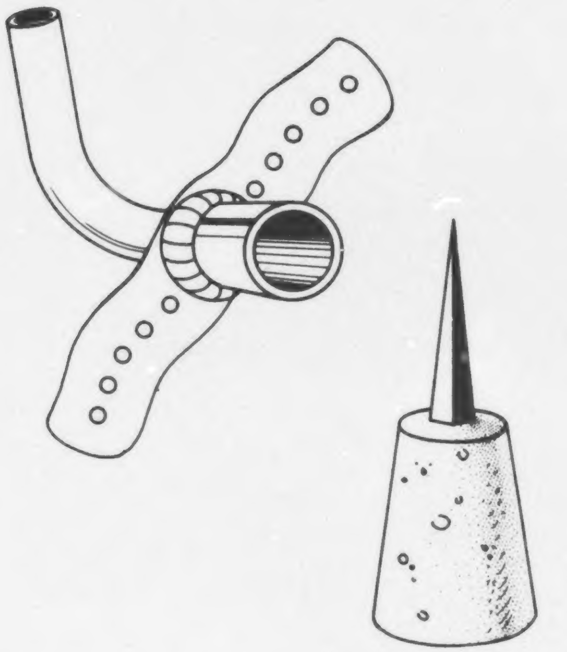


Figure 21. Another Criothyroidotomy Kit

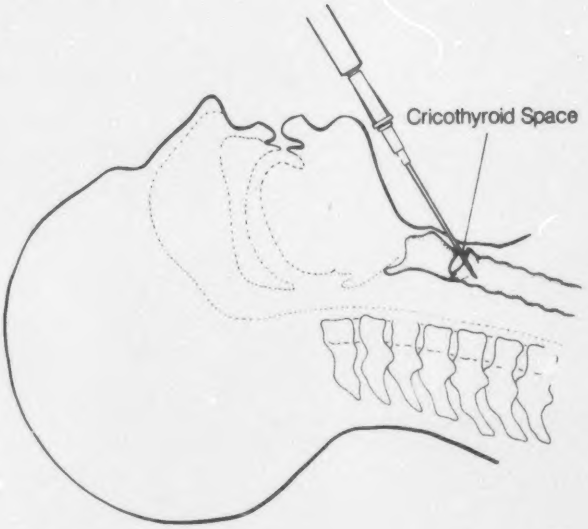


Figure 22. 14 Gauge Catheter Insertion

- Close the valve to accomplish expiration. This stops the gas flow and permits passive exhalation secondary to elastic recoil of the lungs and chest wall. The inflation: deflation time ratio should approximate that of normal respiration—that is, 1:2.

Like cricothyrotomy, transtracheal jet insufflation is potentially hazardous. Therefore, it should be performed only by persons trained in the animal laboratory and authorized by their physician advisers to perform the technique in the field.

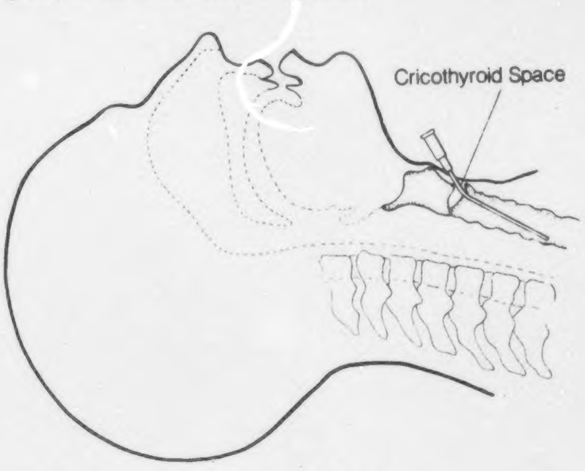


Figure 23. Transtracheal Insufflation

## Glossary

**alveolus:** A socket for the teeth made of bone; a lung air cell (plural: alveoli).

**angioneurotic edema:** A condition of allergic origin, characterized by hives and swelling of various tissues; may involve laryngeal edema, facial swelling, and, sometimes, vascular collapse.

**apnea:** A cessation of breathing; the absence of respiration; usually temporary.

**atelectasis:** A collapse of the lungs, alveolar air sacs.

**bronchospasm:** A severe constriction of the bronchial tree.

**bronchus:** One of the two main branches of the trachea that lead to the right and left lungs; any of the larger air passages of the lungs.

**carina tracheae:** The point where the trachea bifurcates into the right and left mainstem bronchi.

**cricothyroid membrane:** The fibrous portion of the larynx.

**cyanosis:** A blueness of the skin due to insufficient oxygen in the blood.

**dyspnea:** A difficulty in breathing, with rapid shallow respiration.

**epiglottis:** The lidlike cartilaginous structure overhanging the superior entrance to the larynx and serving to prevent food from entering the larynx and trachea while swallowing.

**flail chest:** A condition in which several ribs are broken, each in at least two places; or a sternal fracture or separation of the ribs from the sternum producing a free or floating segment of the chest wall that moves paradoxically on respiration.

**hemothorax:** A bleeding into the pleural cavity.

**hypercarbia:** An excessive amount of carbon dioxide in the blood; a carbon dioxide pressure greater than 45 to 50 torr.

**hyperpnea:** An increased depth of respiration.

**hyperventilation:** An increased rate and depth of breathing resulting in an abnormal lowering in arterial carbon dioxide pressure.

**hypocarbia:** An abnormally low carbon dioxide pressure in the blood.

**hypoventilation:** A reduced rate and depth of breathing resulting in a rise in arterial carbon dioxide pressure.

**hypoxemia:** An inadequate oxygen supply in the blood; an arterial oxygen pressure of less than 60 torr.

**laryngeal edema:** An excessive amount of tissue fluid in the larynx.

**laryngospasm:** A severe constriction of the larynx, often in response to allergy or noxious stimuli.

**larynx:** The organ of voice production.

**minute volume:** The volume of air inhaled and exhaled during 1 minute, calculated by multiplying tidal volume by respiratory rate.

**open pneumothorax:** A pneumothorax caused by an opening in the chest wall; a sucking chest wound.

**orthopnea:** A severe shortness of breath or difficulty in breathing when lying down; relieved by placing the patient in a sitting position.

**paradoxical respiration:** Respiration occurring in an open chest wound, where lung fills on expiration and deflates on inspiration.

**pharynx:** The portion of the airway between the nasal cavity and the larynx; consists of the nasopharynx, oropharynx, and laryngopharynx.

**pneumothorax:** An accumulation of air in the pleural cavity, usually entering after a wound or injury that causes a penetration of the chest wall or laceration of the lung.

**rales:** An abnormal breath sound produced by the flow or air through alveoli and bronchioles when they are constricted by spasm or filled by secretions.

**rhonchi:** A coarse rattling sound somewhat like snoring, usually caused by secretions in the bronchial tubes.

**shunt:** A situation in which a portion of the output of the right heart reaches the left heart without being oxygenated in the lungs; may be due to atelectasis, pulmonary edema, or a variety of other factors.

**stridor:** A harsh, high-pitched respiratory sound associated with severe upper airway obstruction (such as laryngeal edema).

**subcutaneous emphysema:** A condition in which trauma to the lung or airway results in the escape of air into body tissues, especially the chest wall, neck, and face; a crackling sensation will be felt on palpation of the skin.

**sucking chest wound:** See open pneumothorax.

**tachypnea:** Excessively rapid rate of respiration (over 25 per minute in adults).

**tension pneumothorax:** A situation in which air enters the pleural space through a defective oneway valve in the lung causing progressive increase in intrapleural pressure, with lung collapse and impairment of circulation.

**tidal volume:** The amount of air inhaled or exhaled during any level of activity; the volume of one breath at rest (resting tidal volume) is about 500 ml.

**trachea:** The cartilaginous tube extending from the larynx to its division into the mainstem bronchi; the windpipe.

**wheeze:** A high-pitched, whistling sound characterizing an obstruction or spasm of the lower airways.

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# APPENDIX A

## AMERICAN HEART ASSOCIATION CPR ECC CRITICAL PERFORMANCE RATIONALE OBSTRUCTED AIRWAY

### I. CONSCIOUS VICTIM, SITTING OR STANDING: COMPLETE AIRWAY OBSTRUCTION

| Elapsed Time (Seconds) | | Activity and Time (Seconds) | Critical Performance | Rationale |
|---|---|---|---|---|
| Min. | Max. | | | |
| 2 | 3 | Rescuer asks: "Can you speak?" (2–3). | Rescuer must identify complete airway obstruction by asking victim if he is able to speak. | |
| 5 | 8 | 4 back blows (3–5). | Deliver 4 sharp blows rapidly and forcefully to the spine between the shoulder blades; support victim's chest with other hand. | |

### I. CONSCIOUS VICTIM, SITTING OR STANDING: COMPLETE AIRWAY OBSTRUCTION

| Elapsed Time (Seconds) | | Activity and Time (Seconds) | Critical Performance | Rationale |
|---|---|---|---|---|
| Min. | Max. | | | |
| 13 | 18 | 4 abdominal thrusts (8–10). | Stand behind victim and wrap your arm around his waist. Grasp one fist with your other hand and place thumb side of fist between xiphoid and umbilicus. Press fist into abdomen with quick upward thrusts. | The sequence of back blows and abdominal (or chest) thrusts may be more effective than either maneuver used alone. |
| 13 | 18 | Alternative to abdominal thrust—if chest thrusts are indicated: (8–10). | Wrap your hands under victim's arms to encircle lower chest. Grasp one fist with other hand, thumb side on lower sternum. Press with quick backward thrusts. | Chest thrusts are more easily delivered than are abdominal thrusts when the abdominal girth is large, as in gross obesity or in advanced pregnancy. |

## I. CONSCIOUS VICTIM, SITTING OR STANDING: COMPLETE AIRWAY OBSTRUCTION

| Elapsed Time (Seconds) Min. | Max. | Activity and Time (Seconds) | Critical Performance | Rationale |
|---|---|---|---|---|
| 24 | 33 | Alternate until effective, or victim loses consciousness. Seconds for each complete sequence: (11–15). | Repeat above maneuver in rapid sequence. | Time is of the *essence:* the two techniques are rapidly repeated alternately until obstruction is relieved or unconsciousness occurs. |
| II. VICTIM LOSES CONSCIOUSNESS | | | | |
| 10 | 12 | Place in supine position, open airway and attempt to ventilate: (10–12). | Head-tilt method for opening airway. Airway remains obstructed (Modified jaw thrust if necessary, e.g., in suspected cervical spine injury). | Complete airway obstruction by a foreign body is assumed present, but at this point an attempt must be made to get some air into the lungs. |
| 14 | 18 | 4 back blows (4–6). | Roll victim toward you, using your thigh for support. Give 4 forceful and rapidly delivered blows to spine between shoulder blades. | |

## II. VICTIM LOSES CONSCIOUSNESS (Continued)

| Elapsed Time (Seconds) Min. | Max. | Activity and Time (Seconds) | Critical Performance | Rationale |
|---|---|---|---|---|
| 24 | 30 | 4 abdominal thrusts (10–12). | Turn victim supine. Position yourself with knees close to victim's hips. Place heel of one hand between xiphoid and umbilicus and second hand on top. Press into abdomen with quick upward thrusts. Correct hand placement is critical. | Kneeling at victim's side gives the rescuer greater mobility and access to the airway. |
| 24 | 30 | Alternative to abdominal thrust—if chest thrusts indicated: (10–12). | Turn victim supine. Open the airway and turn the head to one side. Hand position for and application of chest thrust is the same as that for applying closed chest heart compression (heel of hand on lower half of sternum). Exert 4 quick downward thrusts that will compress the chest cavity. | There are no significant differences in the airway flow, pressure, and volume between abdominal and chest thrusts. The chest thrust is preferred for special circumstances i.e., advanced pregnancy or marked obesity. |

## II. VICTIM LOSES CONSCIOUSNESS
(Continued)

| Elapsed Time (Seconds) | | Activity and Time (Seconds) | Critical Performance | Rationale |
|---|---|---|---|---|
| Min. | Max. | | | |
| 30 | 38 | Check for foreign body: (6–8). | Turn head to side, open mouth with crossed-finger or jawlift technique and sweep deeply into mouth with hooked finger. | A dislodged foreign body may now be manually accessible if it has not been expelled. |
| 33 | 43 | Attempt to ventilate: (3–5). | Reposition head using head-tilt and attempt ventilation. Airway remains obstructed. | By this time another attempt must be made to get some air into the lungs. |
| 54 | 74 | 4 back blows<br>4 abdominal or chest thrusts.<br>Check for foreign body.<br>Attempt to ventilate.<br>Seconds for each complete sequence: (21–31). | Repeat these maneuvers in rapid sequence. | Persistent attempts are rapidly made in sequence in order to relieve the obstruction. |

## III. UNCONSCIOUS VICTIM—UNWITNESSED

| | | | | |
|---|---|---|---|---|
| 4 | 10 | Establish unresponsiveness. Allow 4 to 10 seconds if turning is required. | Shake shoulders. Shout: "Are you OK?" Call for help. | |
| 7 | 15 | Open airway. Establish breathlessness: (3–5). | Head-tilt method. Rescuer's ear over victim's mouth. | |

## III. UNCONSCIOUS VICTIM-UNWITNESSED
(Continued)

| Elapsed Time (Seconds) | | Activity and Time (Seconds) | Critical Performance | Rationale |
|---|---|---|---|---|
| Min. | Max. | | | |
| 10 | 20 | Attempt to ventilate: (3–5). | Attempt ventilation again. Airway remains obstructed. | Instructor informs student that the airway is blocked. |
| 13 | 25 | Reposition head and reattempt ventilation: (3–5). | Further head-tilt; airway remains obstructed. (Modified jaw thrust if necessary; e.g., in suspected cervical spine injury.) | Inadequate head-tilt may be the cause of block at this point. It may be quickly and simply corrected. Students should also know how to perform the jaw thrust. |
| 17 | 31 | 4 back blows (4–6). | Same as previously described. | |
| 27 | 43 | 4 abdominal thrusts (10–12). | Same as previously described. | The sequence remains the same as in the victim who loses consciousness in your presence. |
| 27 | 43 | Alternative to abdominal thrust—if chest thrusts are indicated (10–12). | Same as previously described. | |
| 33 | 51 | Check for foreign body: (6–8). | Same as previously described. | |
| 36 | 56 | Attempt to ventilate: (3–5). | Head-tilt method. Airway remains obstructed. | An attempt must be made by this time to get air into the lungs. |

## III. UNCONSCIOUS VICTIM-UNWITNESSED
(Continued)

| Elapsed Time (Seconds) |  | Activity and Time (Seconds) | Critical Performance | Rationale |
|---|---|---|---|---|
| Min. | Max. |  |  |  |
| 57 | 87 | 4 back blows<br>4 abdominal or chest thrusts.<br>Check for foreign body.<br>Attempt to ventilate.<br>Seconds for each complete sequence: (21-31). | Repeat these maneuvers in rapid sequence. | Persistent and rapid sequential back blows and manual thrusts are followed by checks for foreign body and attempts to ventilate. |

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# Module VI.
# Cardiovascular System

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# Module VI.

# Cardiovascular System

## Unit 1. Anatomy and Physiology

The cardiovascular system is composed of the heart and blood vessels. The function of the cardiovascular system is to transport blood through the body.

### Circulatory System

In the process of circulation, the blood carries certain nutrients (e.g., glucose and proteins) and oxygen to the cells, and carries carbon dioxide and metabolic

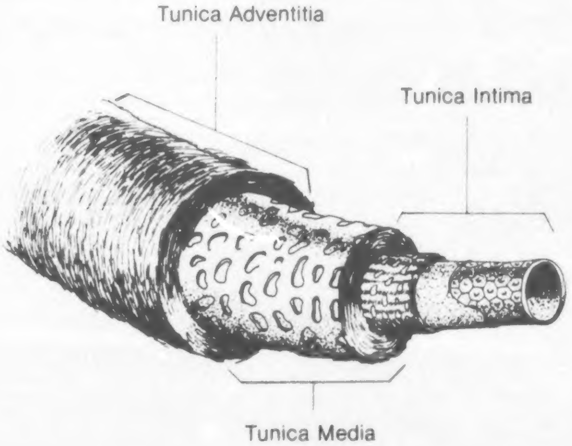

Tunica Adventitia
Tunica Intima
Tunica Media

**Figure 1. Blood Vessel in Cross-Section**

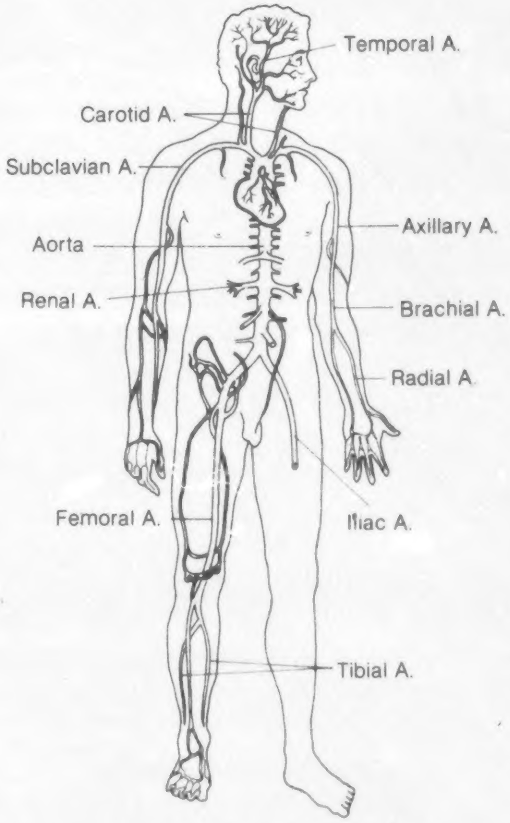

Temporal A.
Carotid A.
Subclavian A.
Axillary A.
Aorta
Renal A.
Brachial A.
Radial A.
Femoral A.
Iliac A.
Tibial A.

**Figure 2. The Arterial System**

waste products away from them. The blood also carries hormones (e.g., epinephrine) that aid in regulating body processes and antibodies that protect the body from infections.

The vessels that carry blood away from the heart are called arteries. Vessels that return blood to the heart are called veins. The capillaries are blood vessels that connect the arterial and venous systems.

The walls of the arteries and veins are composed of three layers of tissue. The inner layer is called the tunica intima and forms a smooth, thin lining. The middle layer, the tunica media, is the thickest of the three tissue layers. It is composed of elastic tissue and smooth muscle cells that allow the vessels to expand or contract in response to changes in blood pressure and tissue demand. The outer layer of tissue is called the tunica adventitia and consists of elastic and fibrous connective tissue. This layer gives the vessel strength to withstand high blood pressure (see Fig. 6.1).

A lumen is a cavity or channel within a tubular organ, the size or diameter of which varies with the size of the organ. The changes in the size of the lumina in the arteries play an important role in regulating blood pressure.

The arteries have thicker walls than the capillaries and veins, because they transport blood at higher pressure. The primary function of the large arteries is to conduct blood to smaller arteries called arterioles, which conduct the blood to the capillaries. A second function of the arteries is to regulate blood pressure through changes in peripheral resistance. Since the arterial system functions to deliver blood to the body, there are no valves in the arteries. Approximately 15 percent of the body's blood is contained in the arterial system at any one time (see Fig. 6.2).

The arterioles terminate in tiny, thin-walled vessels called capillaries. Capillaries are composed of only one layer of tissue called the tunica intima. The lumina of the capillaries are so small that the red blood cells can pass through only in single file, allowing the ready exchange of oxygen, nutrients, and waste products between blood and body cells through the capillary walls.

The network of capillaries (the capillary bed) contains 5 percent of the body's blood. At the end of the capillary beds are the smallest of the veins, called the venules (see Fig. 6.3).

The veins, like the arteries, are composed of three tissue layers. Unlike the arteries, however, the walls of the veins are relatively thin, since they carry blood at low pressure. The venules empty into larger veins that flow into still larger veins that ultimately empty into the two major veins of the body, the superior vena cava and the inferior vena cava. Since the pressure in the veins is low, these vessels contain one-way valves that prevent the backflow of blood. Muscular contraction of the extremities aids in the flow of venous blood back to the heart. The venous system contains 80 percent of the body's blood and serves as a blood reservoir (see Fig. 6.4).

The circulatory system has two major components—the pulmonary circulation and the systemic circulation. The pulmonary circulation consists of blood that is pumped to the lungs and blood that is returned to the heart. The systemic circulation consists of blood

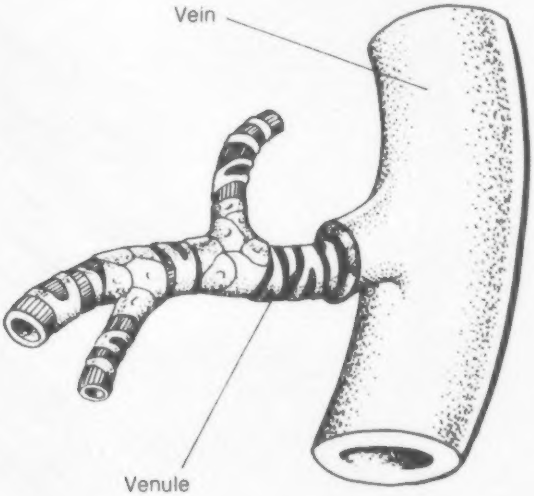


**Figure 3. The Venous System**

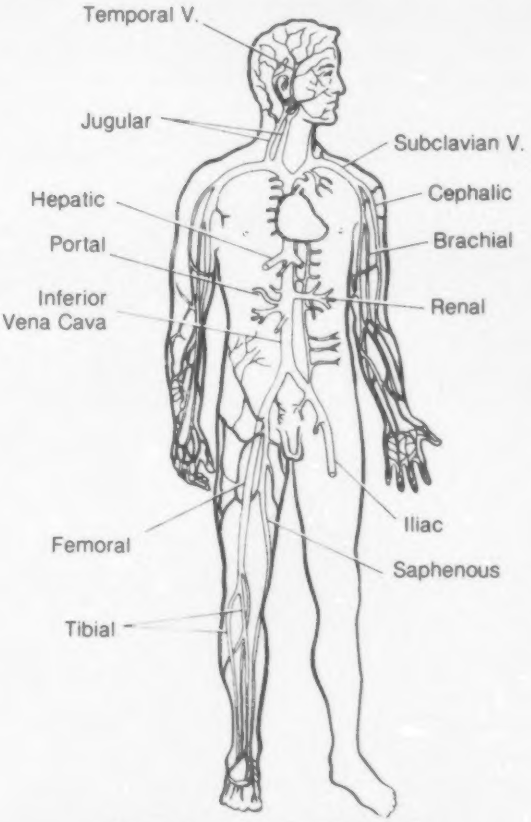


**Figure 4. Venous System**

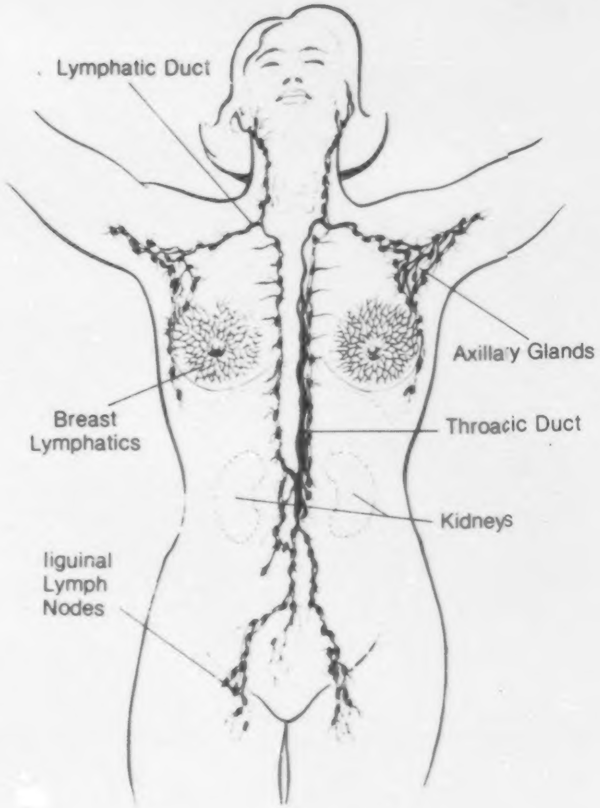


**Figure 5. Lymphatic System**

that is pumped to the rest of the body and is returned to the heart.

Although the circulatory system is sometimes considered a "closed" fluid system, there is a large amount of plasma protein lost through the capillary beds into the interstitial spaces. The only way this lost blood can be returned to the circulatory system is through the lymphatic system. The lymphatic capillaries originate in the interstitial space. These capillaries empty into larger lymphatic vessels, have thin walls, and contain valves. Lymph ultimately is emptied into two main vessels, the right lymphatic duct and the thoracic duct. These two ducts empty into the right and left subclavian veins, respectively. Thus, the lymphatic system assists the venous system by returning the lost protein in the blood (see Fig. 6.5).

## Heart

The heart is a cone-shaped, hollow, muscular organ located in the mediastinum, the central section of the thorax. The heart is rotated on its side and lies on the diaphragm in front of the trachea and esophagus and between the lungs. The base, or top of the heart, lies behind the sternum at the level of the third rib. The apex, or bottom of the heart, lies at the level of the fifth rib in the left midclavicular line (see Figs. 6.6 and Fig. 6.7).

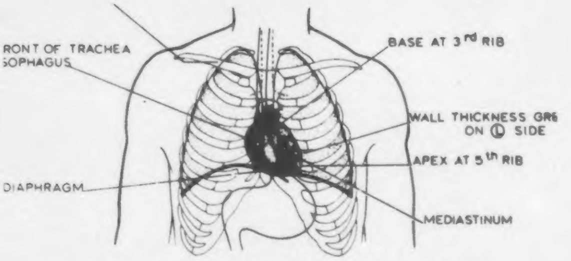


**Figure 6. Location of the Heart in the Thorax**

Although the size of the heart varies from person to person, on an average it is about 10 to 12 centimeters (cm) long, 9 cm wide, and 6 cm thick. It weighs about 300 grams (g) in males and about 250 g in females. The size of the heart may be visualized as approximately the size of its owner's fist.

The heart is encased in a double-walled sac called the pericardium. Enveloping the lungs, like the pleura, the pericardium is composed of two layers. The outer layer, the parietal pericardium, is in direct contact with the pleura and is attached to the diaphragm and sternum. The inner layer, or visceral pericardium, surrounds the heart. Separating the two pericardial layers is a space filled with pericardial fluid. This fluid acts as a lubricant and allows the heart to contract without producing friction. The pericardium can become inflamed as a result of some disease processes; this situation will produce friction when the heart contracts, causing a pericardial friction rub that can be heard with a stethoscope.

The wall of the heart is composed of three muscle layers: the epicardium, the myocardium, and the endocardium. The epicardium is the outer layer of the heart and is the same as the visceral pericardium. The epicardium consists of elastic fibers and some fat deposits. The middle layer of the heart is called the myocardium. It is the thickest of the three layers and is composed of cardiac muscle fibers that provide the force that pumps the blood. The endocardium is the inner layer of the heart. It is composed of thin con-

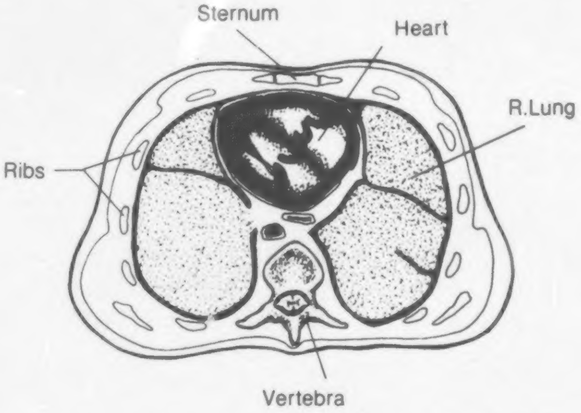


**Figure 7. Location of the Heart in the Thorax (Cross-Section)**

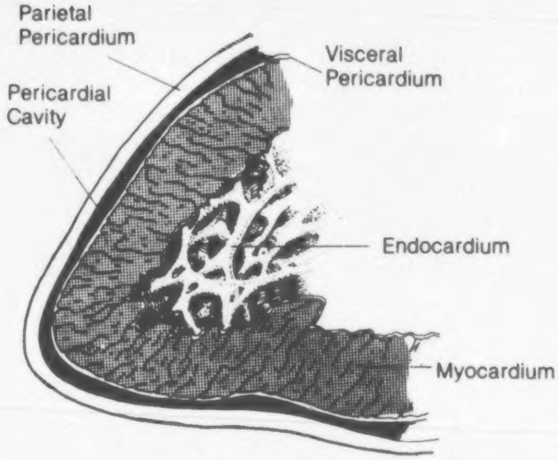


**Figure 8. Heart Wall**

nective tissue and forms the inner surface of the heart and the heart valves (see Fig. 6.8).

The heart consists of four hollow chambers and two pumping systems. The two atria or upper chambers are located at the base of the heart; the two ventricles are located at the apex. The right and left atria are thin-walled chambers that receive blood returning to the heart. The larger, thick-walled right and left ventricles pump the blood away from the heart. Of the four chambers, the left ventricle has the thickest walls since it is the chamber that pumps blood through the systemic circulation (see Fig. 6.9).

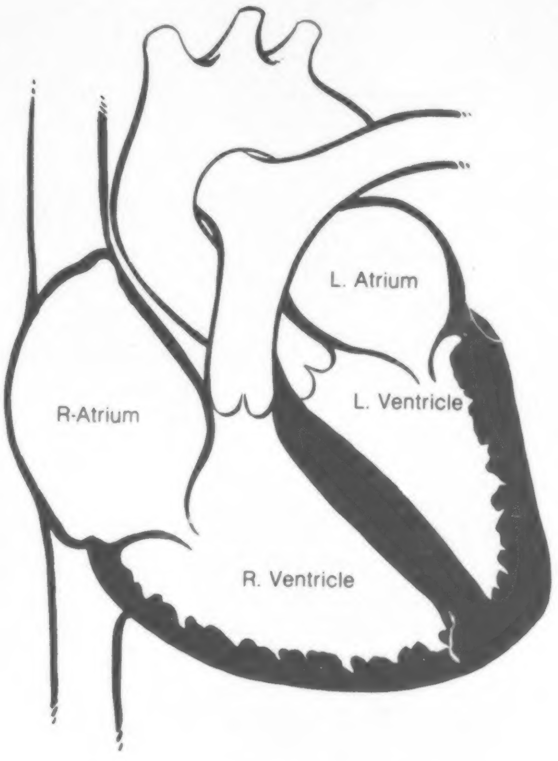


**Figure 9. Heart in Cross-Section**

The heart can also be thought of as divided into two pumps by a lengthwise wall of muscular tissue called the septum. Each side is composed of one atrium and one ventricle. The part of the septum separating the two atria is called the interatrial septum; the part separating the two ventricles is called the interventricular septum.

The heart chambers are also separated externally. The atria are divided from the ventricles by the atrioventricular groove. The ventricles are separated externally by the anterior and posterior interventricular grooves. The muscle fibers of the two atria and the ventricles are continuous. It is this external separation that allows the atria and ventricles to contract independently.

The heart is supplied with blood from two main arteries, the coronary arteries. These arteries originate from the base of the ascending aorta immediately above the leaflets or cusps of the aortic valve. The left coronary artery branches off the left cusp of the aorta and travels over and in front of the heart. The left coronary artery bifurcates or divides into two main branches—the anterior descending branch and the circumflex branch.

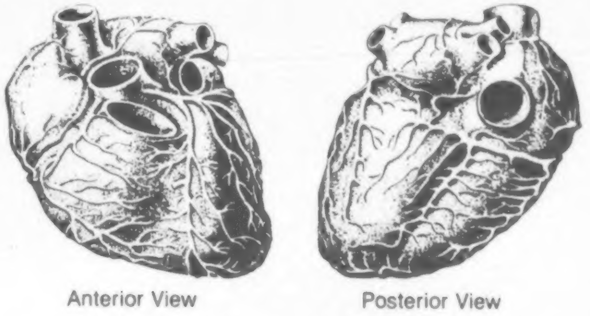

Anterior View
Posterior View

**Figure 10. Heart Showing the Coronary Arteries**

The left anterior descending branch supplies blood to the left ventricle and the interventricular septum. The left circumflex branch supplies blood to the left atrium and to the lateral wall of the heart.

The right coronary artery branches off the right cusp of the aorta and travels behind the heart where it divides into a posterior descending branch and a right margin branch. The right coronary artery supplies blood to the right atrium and the right ventricle (see Fig. 6.10 and Table 6.1).

Interconnections (anastomoses) between the coronary arteries are called the coronary collateral vessels. These secondary arteries can enlarge to provide blood to regions of the heart whose blood supply is decreased as a result of an occlusion of one of the main coronary arteries.

The coronary arteries and the veins draining the heart empty into the coronary sinus, a large cardiac vein. This vein drains into the right atrium.

## Table 6.1

**Types of Infarction and Complications of Coronary Arteries**

| Coronary Artery | Major Areas and Structures Supplied |
|---|---|
| Right coronary artery | SA node (60 percent).<br>AV node (90 percent).<br>Bundle of His.<br>Right atrium and right ventricle.<br>Inferior surface of left ventricle.<br>Posterior one-third of septum. |
| Left anterior descending artery | Anterior wall of the left ventricle.<br>Anterior two-thirds of septum.<br>Bundle of His.<br>Right bundle branch. |
| Left circumflex artery | SA node (40 percent).<br>AV node (10 percent).<br>Lateral wall of left ventricle.<br>Left atrium. |

The heart has four valves that allow blood to flow in only one direction. These are the tricuspid, mitral, pulmonic, and aortic valves. The two atrioventricular valves, the tricuspid and the mitral valves, are located between the atria and the ventricles. The two semilunar valves, the pulmonic and aortic valves, are located between the ventricles and the major arteries.

The tricuspid valve, named for its three cusps or sections, is located between the right atrium and the right ventricle. The cusps form a ring around the atrioventricular opening, and their free edges protrude into the ventricle. These free edges are attached to the chordae tendineae, fine tendinous chords of dense connective tissue that attach to papillary muscles in the ventricular wall. The chordae tendineae and the papillary muscles prevent the cusps from flopping backward into the atrium, which would result in inadequate functioning of the valve. Blood could then flow from the atrium into the ventricle—in two directions rather than in one.

The mitral valve is located between the left atrium and left ventricle. It is structurally similar to the tricuspid valve, but has only two cusps.

The pulmonic valve is located between the right ventricle and the pulmonary artery. The aortic valve is located between the left ventricle and the aorta. Like the atrioventricular valves, the semilunar valves are composed of dense connective tissue. These valves, however, differ structurally from the atrioventricular valves in that each semilunar valve has three pocket-shaped cusps or leaflets. The lower border of each cusp attaches to the arterial wall and the upper borders swing free (see Fig. 6.11).

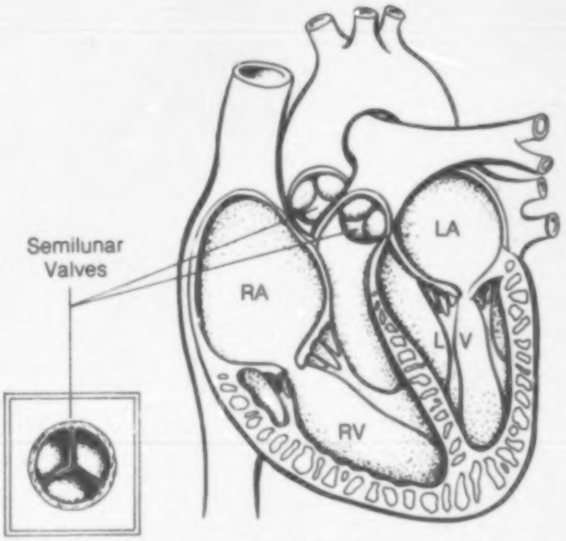


**Figure 11. Structural Construction of the Semilunar Valves**

The opening and closing of the valves are regulated by pressure changes in the heart chambers. When the ventricles contract (ventricular systole), the mitral and tricuspid valves close. When the pressure in the ventricles exceeds the pressure in the aorta and pulmonary artery, the pulmonic and aortic valves open. When this process takes place, some of the blood is ejected from the ventricles into the aorta and the pulmonary artery. When the pressure in the ventricles becomes less than the pressure in the aorta and the pulmonary artery, the aortic and pulmonic valves close.

Blood flows continuously into the atria from the great vein. During ventricular systole, blood accumulates in the atria because the atrioventricular valves are closed. After ventricular systole, the ventricles relax (diastole). At this time, the pressure in the atria begins to exceed the pressure in the ventricles causing the mitral and tricuspid valves to open. The blood that has accumulated in the atria rushes into the ventricles, and the cyclic changes in pressures continue (see Fig. 6.12).

In summary, during ventricular systole (contraction), the aortic and pulmonic valves are open and the tricuspid and mitral valves are closed. During ventricular diastole (relaxation), the aortic and pulmonic valves are closed and the mitral and tricuspid valves are open. It is important to note that the coronary arteries fill passively during ventricular diastole.

As mentioned earlier, the heart can be considered a two-pump system—a low-pressure pump on the right side and a high-pressure pump on the left side. The

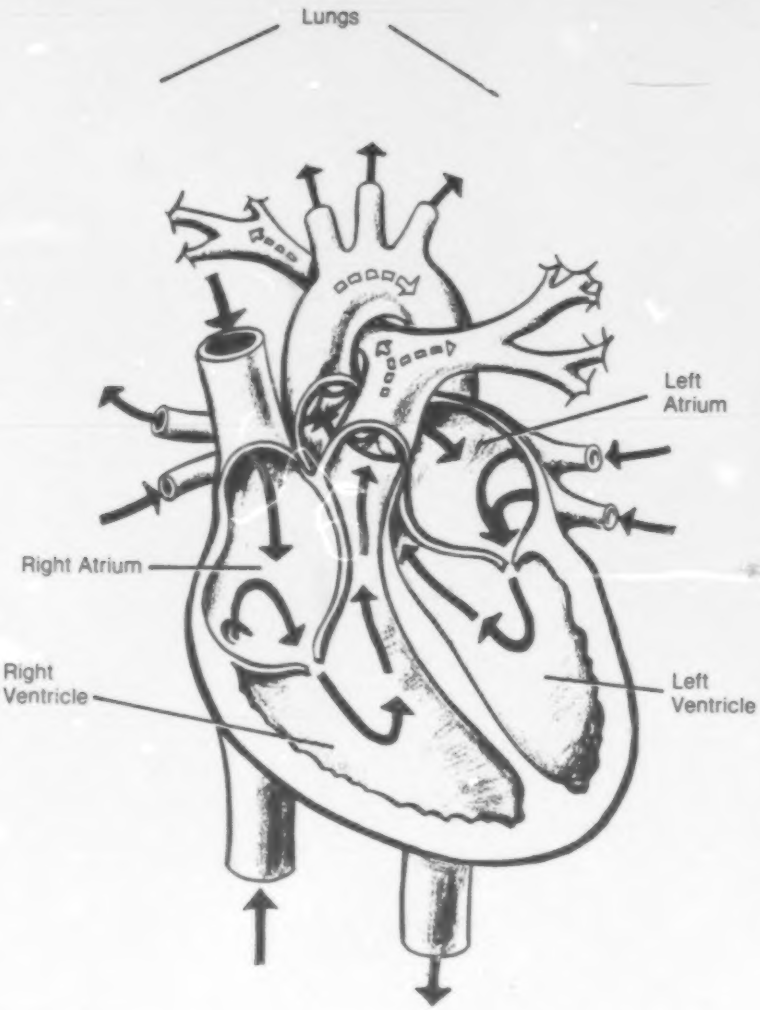


Figure 12. How the Blood Moves from the Atria to the Ventricles

right heart pumps blood into the pulmonary circulation; the left heart pumps blood into the systemic circulation.

Unoxygenated blood is returned to the right atrium by three main veins: (1) the superior vena cava that drains unoxygenated blood from the upper part of the body, (2) the inferior vena cava that returns the blood from the lower part of the body, and (3) the coronary sinus that returns the unoxygenated blood from the heart itself.

When the right atrium contracts, the tricuspid valve opens and permits the unoxygenated blood to flow into the right ventricle. The right ventricle then fills with blood. When the right ventricle begins to contract, the tricuspid valve closes and the pulmonic valve opens. This action permits the unoxygenated blood to enter the right and the left pulmonary arteries located at the base of the right ventricle. The blood is then pumped into the lungs. The pulmonary circulation is also known as the "lesser" circulation because less pressure—approximately 30 millimeters of mercury (mm Hg)—is required to pump blood to the lungs than to the rest of the body. The right side of the heart thus functions as a low-pressure pump system.

When the unoxygenated blood reaches the lungs, carbon dioxide leaves the blood and oxygen enters through the capillary bed. The unoxygenated blood then becomes oxygenated. The blood then flows into the pulmonary veins, returns to the heart, and enters the left atrium.

As the left atrium contracts, the mitral valve opens and permits the oxygenated blood to flow into the left ventricle, which then fills with blood. When the left ventricle begins to contract, the mitral valve closes and the aortic valve opens. This action permits the oxygenated blood to enter the aorta, which is located at the base of the left ventricle. Oxygenated blood is then pumped to the rest of the body—head and neck, upper extremities, thorax, digestive tract, liver, kidneys, lower extremities, and the heart itself. This circulation is known as the systemic circulation or "greater" circulation. The amount of pressure that must be generated to pump blood to the rest of the body is quite high, approximately 120 mm Hg. Thus, the left side of the heart functions as a high-pressure pump system.

To review, the oxygenated blood flows through the aorta into the coronary arteries, systemic arteries, arterioles, and capillaries. Oxygen is given up to the tissues, and carbon dioxide and waste products enter the blood at the capillary level. The unoxygenated blood is returned to the heart via the venules and veins, which terminate in the superior and inferior venae cavae. Unoxygenated blood then enters the right atrium and the process continues. Blood is never directly exchanged between the right and left sides of the heart.

## Cardiac Cycle

Although each side of the heart may be considered as a separate pump, both sides, in fact, work in parallel. That is, both atria contract simultaneously, followed by both ventricles. The actual time sequence between ventricular contraction (systole) and relaxation (diastole) is called the cardiac cycle.

As previously described, during ventricular diastole, the ventricles fill passively with 70 percent of the blood that has accumulated in the atria. Active contraction of the atria forces the remaining 30 percent of the blood into the ventricles. Atrial contraction plays only a small part in ventricular filling; therefore, if the atria do not contract, ventricular filling still occurs. The volume of blood in the ventricles at the end of the diastole is normally 100 to 150 milliliters (ml).

Systole lasts about 0.28 second; diastole, about 0.52 second. Therefore, one cardiac cycle occurs every 0.8 second. At faster heart rates the time for diastole decreases, while the time for systole remains virtually unchanged. Consequently, ventricular filling decreases with fast heart rates.

## Heart Sounds

Closure of the heart valves during the cardiac cycle produces two different heart sounds. These sounds result from the movement of blood when the valves close. Closure of the mitral and tricuspid valves at the beginning of systole produces the first heart sound ("lub"). The second sound ("dub") occurs with the closure of the aortic and pulmonary valves at the beginning of diastole.

## Cardiac Output

Cardiac work is measured by the amount of blood the heart pumps each minute (cardiac output). Since the ventricles contract simultaneously, their outputs are normally equal. Cardiac output (CO) equals stroke volume (SV) multiplied by heart rate (HR).

Stroke volume is the amount of blood pumped by either ventricle during one cardiac cycle or heart beat. Heart rate is the number of contractions or beats, per minute. Stroke volume is normally 60 to 100 ml per beat; the heart rate is usually 60 to 100 beats per minute. Using SV and HR, the paramedic can determine the cardiac output. Therefore, if a person has an SV of 70 ml per beat and an HR of 70 beats per minute, the cardiac output will be approximately 5 liters per minute.

70 ml per beat × 70 beats per minute = 490 ml per minute or approximately 5.1 per minute

Any change in heart rate or stroke volume will effect a change in the cardiac output. For example, an increase in either heart rate or stroke volume will increase the cardiac output.

Stroke volume is the amount of blood pumped by the ventricles with each contraction. An increase in volume in the ventricles causes a more forceful contraction stretching the ventricular myocardial fibers resulting in a more forceful contraction. This principle is referred to as Starling's law. Therefore, using the equation $CO = SV \times HR$, it can be seen that if stroke volume increases but heart rate remains constant, cardiac output will increase. However, if the myocardial muscle fibers are continuously stretched, they lose this responsiveness and contract less forcefully than normal. When this happens, cardiac output will no longer be increased by greater stroke volume.

From the equation $CO = SV \times HR$, it is evident that any change in the heart rate will also affect cardiac output. Normally stroke volume is decreased by rapid heart rates. Theoretically, if stroke volume remains constant, cardiac output will be increased by an increase in heart rate.

## Blood Pressure

Arterial blood pressure changes during the cardiac cycle. The higher pressure that is reached during ventricular systole is the systolic blood pressure; the lower pressure that is reached during ventricular diastole is the diastolic blood pressure. The difference between the systolic and diastolic blood pressure is called the pulse pressure.

Blood pressure (BP) is determined by cardiac output (CO) and peripheral vascular resistance (PVR). Peripheral vascular resistance refers to the amount of opposition to blood flow offered by the arterioles. Peripheral vascular resistance is determined by arteriole vasoconstriction and vasodilation. The interrelationship between BP, CO, and PVR are major factors in maintaining adequate tissue perfusion. This interrelationship can be expressed in the following equation:

$BP = CO \times PVR$ If cardiac output or peripheral vascular resistance changes, blood pressure will also change.

Blood pressure will increase or decrease if cardiac output increases or decreases, provided that peripheral vascular resistance remains constant.

If cardiac output remains constant, blood pressure will increase or decrease in response to changes in peripheral vascular resistance. If the arterioles dilate, peripheral vascular resistance to blood flow will be decreased and blood pressure will decrease. With vasoconstrictions, there is an increase in resistance to blood flow, thus, blood pressure will increase.

## Pulse

The pulsation palpated with the fingertips over an artery represents the expansion and recoil of the elastic arterial wall and also gives a measure of the heart rate. With ventricular contraction, the ejected blood expands the walls of the aorta and is transmitted as a pressure wave. This pressure wave cannot be felt in the veins or capillaries, because it has been damped out by the time it reaches these vessels.

The pulse should be described according to its rate (fast or slow), its strength (weak and thready; strong and bounding), and its rhythm (regular or irregular).

## Nervous Control

The autonomic nervous system relates the activity of the visceral organs and the blood vessels. The autonomic nervous system also assists the body in adapting to changing physiological conditions. As discussed in Module VIII, there are two divisions of the autonomic nervous system—the sympathetic nervous system and the parasympathetic nervous system. Almost all the organs of the body are innervated by both divisions; however, each division is antagonistic in action to the other.

The sympathetic nervous system has two types of receptor fibers at its nerve endings—the alpha and beta receptors. When the sympathetic nervous system is stimulated, norepinephrine is released to transmit the impulse at the nerve ending. Nerve endings that secrete norepinephrine are called adrenergic. When the parasympathetic nervous system is stimulated, acetylcholine is released. When acetylcholine is secreted, the nerve ending is referred to as cholinergic. There are also a few sympathetic nerve fibers that release acetylcholine.

All the blood vessels, except capillaries, have alpha-adrenergic receptors. When these receptors are stimulated, vasoconstriction occurs. The heart and lungs have beta-adrenergic receptors. When they are stimulated, the heart rate increases and the bronchioles dilate.

Blood flow may be regulated either by the autonomic nervous system or by internal hormonal mechanisms such as epinephrine. Because the heart and brain are very sensitive to hypoxia, blood flow to these two organs is regulated mainly by internal mechanisms or changes in oxygen pressure ($PO_2$) or carbon dioxide pressure ($PCO_2$). Cerebral and coronary arterioles dilate in response to either decreased $PO_2$ or increased $PCO_2$.

Pulmonary blood flow is also regulated mainly by changes in $PO_2$ or $PCO_2$. Pulmonary blood vessels, however, constrict in response to decreased $PO_2$ or increased $PCO_2$. This response will shift blood to better ventilated alveoli where carbon dioxide and oxygen exchange can occur.

Blood flow through the skin, kidneys, visceral organs, and skeletal muscles is regulated mainly by the sympathetic nervous system. Arterioles in the skin, kidneys, and visceral organs is reduced. In arterioles contained in skeletal muscle, beta-adrenergic receptors predominate. These arterioles dilate in response to sympathetic nervous stimulation, which increases blood flow through skeletal muscles.

Blood pressure equals total peripheral resistance times cardiac output, thus, changes in either cardiac output or arteriolar resistance alter blood pressure. The cardiovascular centers in the brain stem control blood pressure. These centers receive messages from pressure receptors in the aortic arch and the carotid sinuses. These pressure receptors fire more rapidly when the arterial blood pressure increases. The cardiovascular centers respond to these rapid firing rates and stimulate the parasympathetic nervous system causing a slowing of the heart rate and a decrease in myocardial contractility; this in turn results in a fall in cardiac output. In addition, decreased stimulation of alpha and beta adrenergic receptors reduces arteriolar vasoconstriction and results in a decrease in total peripheral resistance. These two effects, decreased cardiac output and decreased peripheral resistance, combine to reduce the blood pressure to normal.

In contrast, when the blood pressure falls, fewer messages from the pressure receptors reach the cardiovascular centers. Therefore, the cardiovascular centers increase sympathetic stimulation to the heart and blood vessels and decrease parasympathetic stimulation. Sympathetic stimulation of the beta receptors in the heart increases contractility of the ventricles. Decreased parasympathetic stimulation, likewise, increases the heart rate, thus increasing cardiac output. Arterioles in the skin, kidneys, and visceral organs constrict in response to alpha-adrenergic stimulation. The net effect is increased total peripheral resistance. These three effects, increased contractility, increased heart rate, and increased peripheral resistance, combine to return the blood pressure to normal.

Hypoxia and carbon dioxide retention also influence blood pressure regulation by the autonomic nervous system. As described in Chapter 5, peripheral chemoreceptors in the aortic and carotic bodies are simulated by decreased $PCO_2$, decreased pH, and increased $PO_2$. Messages from these chemoreceptors reach the cardiovascular centers, which then increase heart rate, force of cardiac contraction, and peripheral resistance. Blood pressure, therefore, rises.

## Electromechanical System of the Heart

The heart has a specialized electrical conduction system that is composed of specialized noncontractile tissue. This electrical network serves to coordinate the contraction of the atria and the ventricles. The electrical conduction system includes the sinoatrial (SA) node, the atrial internodal pathways, the atrioventricular (AV) node within the AV junction, the common bundle of His, the right and left bundle branches, and the Purkinje network consisting of Purkinje fibers and their branches.

The SA node is located at the junction of the superior vena cava and the right atrium. The SA node is normally the dominant pacemaker of the heart. Three atrial internodal pathways transmit the electrical impulse from the SA node to the AV node. The AV node is located on the right side of the interatrial septum just above the coronary sinus opening. The AV node serves to slow the impulses from the SA node to the ventricles. From the AV node, conduction resumes its rapid velocity in the bundle of His. The bundle of His then divides into the right and left bundle branches. These branches terminate in Purkinje fibers.

Like all other organs, the heart is innervated by both sympathetic and parasympathetic nerve fibers. The heart has only beta-adrenergic receptors located in the atria and ventricles. Thus, all sympathetic nervous system effects on the heart are beta-adrenergic effects. When the sympathetic nervous system is stimulated, there is an increase in heart rate and contractility. The parasympathetic nervous system acts on the heart via the vagus nerve. Vagal nerve fibers innervate the SA node, atrial muscle, and the AV node. Stimulation of the parasympathetic nervous system will result in slowing of the heart rate and conduction through the AV node, as well as a decrease in atrial contractility.

## Physiology of the Specialized Conduction System

All atrial muscle cells contract simultaneously; similarly, all ventricular muscle cells contract together. If a stimulus is strong enough for cardiac cells to reach threshold, all cells will respond to the stimulus and contract. (Threshold is the point at which a stimulus will cause the cell to respond.) This phenomenon is called the "all or none" theory of cardiac muscle cells—all cells will respond or none will. Cardiac muscle cells can contract in response to thermal, electrical, chemical, or mechanical stimuli.

Cardiac muscle cells have the special properties of irritability, conductivity, rhythmicity, and automaticity. Irritability and conductivity are described with cell properties in Module II. Rhythmicity is the coordination of the contractions of the cardiac muscle cells to produce a regular heart beat. Automaticity is the ability of cardiac cells to depolarize spontaneously without nervous stimulation. Each group of cardiac cells has an intrinsic or characteristic spontaneous depolarization frequency. When the heart muscle cells depolarize, they normally contract. Therefore, automaticity permits cardiac muscle cells to contract spontaneously without nervous stimulation.

All living cells are surrounded by a semipermeable membrane that serves to maintain the integrity of the cell. The composition of the intracellular compartment differs from that of the extracellular compartment. Potassium is the major intracellular electrolyte. There is 30 times more potassium inside the cell than outside the cell. Sodium is the major extracellular electrolyte. There is 30 times more sodium outside the cell than inside.

As a result of this variation in electrolyte concentration, the interior of the cell is considered to be electronegative, and the exterior is electropositive. This electrical difference must exist in order for the cell to contract (to produce work). When stimulated, the semipermeable membrane becomes more permeable to sodium. This increased permeability results in an influx of positive ions to the intracellular compartment and a flow of negative ions into the extracellular compartment.

The cell at rest is electronegative and retains potassium. Likewise, the exterior of the cell remains electropositive and sodium is kept out of the cell. The cell at rest is said to be polarized.

When a stimulus of sufficient strength causes the cell to reach threshold, depolarization begins. Not all cells, however, respond at the same threshold. When stimulated, the cell membrane becomes more permeable to sodium. When stimulation occurs, sodium begins to rush into the electronegative cell, reversing the membrane potential; the inside of the cell then becomes electropositive. This rapid change in electrical potential from negative to positive is called depolarization. A wave of depolarization moves across the cells causing the cell to produce work.

After contracting, the cell returns to its resting state through the process of repolarization. The cell membrane contains a "pump" that actively ejects sodium from the intracellular compartment back into the extracellular compartment. The inside of the cell returns to its original electronegative state. The cell is again polarized and can be stimulated again (see Fig. 6.13).

During most of the repolarization, the cell cannot respond to any new electrical stimulus nor can it spontaneously depolarize. This phase is called the absolute refractory period of the cell. During the relative refractory period, repolarization is almost complete, and the cell can be stimulated to contract pre-

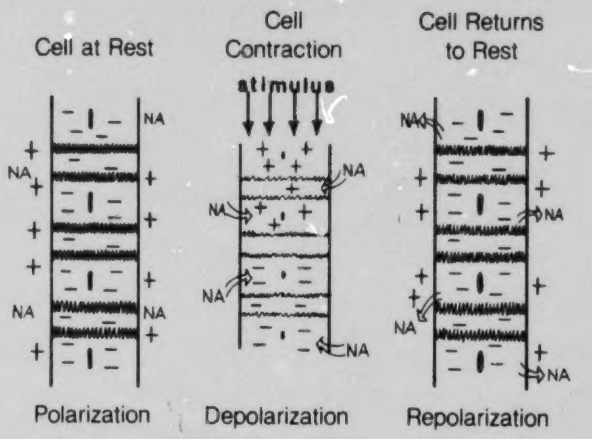


**Figure 13. How the Heart Cells Repolarize and Movement of Sodium**

maturely. However, the stimulus must be stronger than normal. At the end of the repolarization period, the cell becomes very sensitive and can be stimulated by minimal stimuli. Stimulation at the end of the repolarization period will result in loss of effective contraction. This phase of repolarization is identified as the vulnerable period of the cell.

Automaticity of cardiac cells depends on normal extracellular electrolyte concentrations. Normal concentrations of potassium, calcium, and sodium are especially important in maintaining automaticity. Increases in the serum concentrations of these electrolytes increase the level of threshold. Thus, automaticity is decreased. Decreases in serum potassium and calcium decrease the threshold level, thus, also increasing automaticity.

## Cardiac Conduction System (See Fig. 6.14)

Each component of the conduction system has a characteristic or intrinsic spontaneous depolarization rate. The SA node depolarizes at a rate of 60 to 100 times per minute; the AV node depolarizes 40 to 60 times per minute; and the bundle branches at a rate of 20 to 40 times per minute. The SA node is normally the pacemaker of the heart because it reaches threshold first. The wave of depolarization generated by the SA node reaches and stimulates the other cardiac cells before they themselves can depolarize spontaneously. Any area of the heart can become the pacemaker if its depolarization rate becomes faster than the rates of other areas, or if the faster areas fail to depolarize.

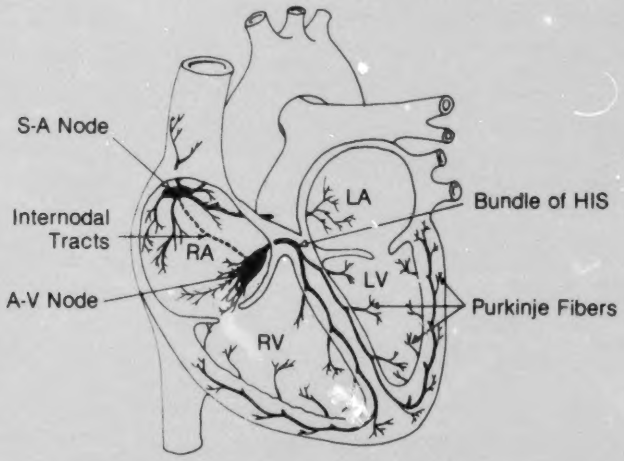


**Figure 14. Cardiac Conduction System**

From the SA node, the wave of depolarization spreads through the atrial muscle and causes the atria to contract, producing atrial systole. Because the atrial and ventricular muscles are separated, impulses from the atrial muscles do not reach the ventricles. Therefore, three atrial internodal pathways carry the electrical impulse from the SA node to the AV node. It takes approximately 0.08 second for the impulse to travel from the SA node to the AV node. The impulse travels through the AV node relatively slowly. This allows the ventricle to fill with blood.

From the AV node, the impulse travels to the bundle of His. From the bundle of His, the impulse is conducted to the right and left bundle branches that, in turn, conduct the impulse to the Purkinje fibers. It takes approximately 0.10 second for the electrical impulse to be conducted through the ventricles. When the Purkinje fibers are stimulated, the ventricles contract.

## Principles of Electrophysiology

Atrial and ventricular depolarization are electrical events that can be sensed by electrodes on the skin surface. If the electrical impulses that reach the electrodes are amplified, they can be recorded in the form of an electrocardiogram (EKG). The EKG is, therefore, a graphic tracing of the electrical activity of the heart but not the mechanical activity; the EKG does not show how well the heart is contracting.

Any wave or complex of waves recorded on the EKG can be referred to as a positive deflection (above the isoelectric baseline) or as a negative deflection (below the isoelectric baseline). A wave of positive charges moving toward a positive electrode will produce a positive deflection or a deflection above the isoelectric baseline on the EKG. If a wave of positive charges moves away from a positive electrode, a downward or negative deflection will be produced below the baseline. The same electrical event in the heart may produce either a positive or negative deflection on the EKG depending on the position of the positive electrode (see Fig. 6.15).

In the following discussion, the components of the EKG as they appear in limb leads I and II will be examined. Electrode placement for these leads is described in the techniques section of this chapter.

During a normal cardiac cycle, the SA node fires first and sends an electrical impulse to stimulate both atria.

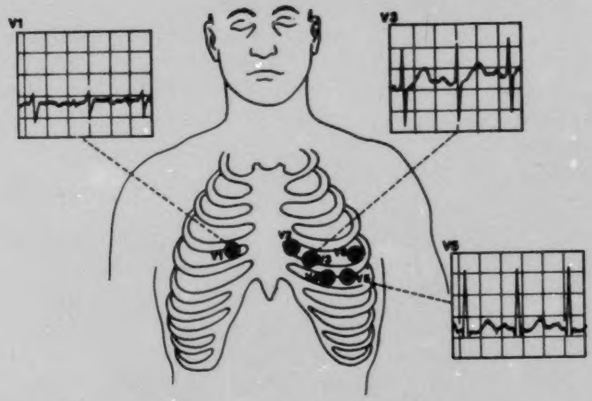


**Figure 15. Relationship of the Positive EKG Electrode to Positive Deflection of the EKG Stylus**

This produces the P wave, a smoothly rounded upward deflection, which is about 0.10 second long. The P wave represents atrial depolarization.

The impulse then reaches the AV node where there is an 0.08 to 0.16-second pause where the impulse travels through the AV node. This allows the ventricles to fill with blood before contracting.

After the pause at the AV node, the electrical impulse is conducted to the bundle of His. From the bundle of His, the impulse travels through the right and left bundle branches, to the Purkinje fibers, and, ultimately, to the ventricular muscle cells. This produces the QRS complex. The QRS complex consists of the Q, R, and S waves. The Q wave is the first downward deflection of the QRS complex. The first upward deflection of the QRS complex is the R wave. The R wave is the largest deflection in leads I and II. Following the R wave, there is a downward deflection, which is the S wave. The QRS complex, thus, represents ventricular depolarization.

After ventricular depolarization, there is a pause shown by the S–T segment. The S–T segment represents the time during which the ventricles are depolarized and ventricular repolarization can begin again. The S–T segment is usually isoelectric, that is, even with the baseline. The T wave, which represents ventricular repolarization, follows the S–T segment. Ventricular repolarization is strictly an electrical event; there is no associated ventricular movement. In leads I and II, the T wave is normally a slightly asymmetrical, slightly rounded, positive deflection.

In summary:

- The P wave represents atrial depolarization.
- The QRS complex represents ventricular depolarization.
- The T wave represents ventricular repolarization.

An atrial T wave representing repolarization follows also the P wave. However, it is not usually visible on the EKG, because it is buried in the QRS complex. The P QRS–T pattern represents one cardiac cycle.

Segments and intervals are also identified on the EKG. A segment is a section of the EKG between waves; an interval is a section of the EKG that usually contains a wave. The S–T segment represents the time from the end of the S wave to the beginning of the T wave. The P–R interval represents the time from the beginning of the P wave to the beginning of the QRS complex. The normal P–R interval ranges from 0.12 to 0.20 second. The R–R interval represents the time interval between two successive QRS complexes. This will be discussed in more detail in Unit 4.

## Unit 2. Patient Assessment

The patient with suspected cardiac disease needs to have as complete a history as possible taken and a physical examination given to provide proper preventive or emergency care if necessary. It is important for the paramedic to remember that other body systems may affect or be affected by the cardiac disease process.

### Current Complaint

Much information regarding the patient's cardiac problem can be gained from the patient's medical history. The most common complaints found in patients suffering from cardiac disease are chest pain, dyspnea, fainting, and palpitations.

Chest pain is often the presenting sign of myocardial infarction. However, other descriptive factors need to be obtained to characterize the patient's condition. These descriptions include the location of the pain, radiation, onset, duration, severity, alleviating factors, aggravating factors, and associated symptoms.

The anatomical location of the pain must be determined. (Does the pain radiate? Does the pain travel to the jaw, down the left arm, into the back?) Onset refers to the time and setting in which the pain first occurred. The onset of chest pain may be sudden or gradual, and it can be precipitated in a variety of settings (after shoveling snow, at rest). Duration refers to the length of time the pain lasts. Severity depends on the subjective analysis of the pain by the patient (feeling of impending doom, squeezing, burning). There may be associated symptoms that also reflect the presence of a cardiac problem (nausea, vomiting, weakness, fatigue). Factors that influence the chest pain include those that aggravate or alleviate the chest pain, as well as medications the patient may have taken to relieve the pain. Finally, it is important to know if the patient has ever experienced this type of pain before, and if so, whether the precipitating factors, the duration, and the severity were the same as in the past. If the patient has a history of chest pain, it is imperative to determine the differences (if any) in the patient's present complaint of chest pain.

Dyspnea, or difficulty in breathing, is another common manifestation of a cardiac problem. Dyspnea may indicate congestive heart failure. As in chest pain, descriptive factors need to be obtained to characterize the patient's condition. These factors include the onset, duration, severity, aggravating factors, alleviating factors, associated symptoms, and prior occurrence.

Onset and duration refer to when and how long the dyspnea occurred. (Did it wake the patient from sleep?) Paroxysmal nocturnal dyspnea (PND) is an acute episode of dyspnea in which the patient suddenly awakens from sleep with a feeling of suffocation. Factors that influence dyspnea include those that alleviate or aggravate the condition—such as changes in body position. Dyspnea that worsens when the patient lies down is referred to as orthopnea and is caused by the pooling of blood in the lungs when the body is horizontal. Frequently, patients with orthopnea will sleep on several pillows to obtain an upright or semiupright position to avoid further exacerbations of dyspnea. Associated symptoms such as coughing or going to a window to breathe may also be present. It is also important for the paramedic to know if the patient has ever experienced this type of dyspnea before and, if so, whether the circumstances differed from those in the present situation. Dyspnea can result from lung disease as well as heart disease. Therefore, the possibility of an existing chronic pulmonary problem as a cause of the present complaint should also be considered.

Syncope, or fainting, occurs when cardiac output is reduced resulting in inadequate cerebral perfusion. Syncope may be due to cardiac arrhythmias, increased vagal tone, or various heart lesions. It must be determined under what circumstances the syncopal episode occurred and whether the episode was preceded by any warning. It is important that the paramedic know the position that the patient was in at the time of the syncopal episode (standing, sitting, lying down). Associated symptoms that may characterize the syncopal episode, such as vomiting, urinary incontinence, or seizure activity, should also be noted. Finally, it is essential that the paramedic know if the patient has ever experienced fainting episodes before, and if so, if the circumstances were similar.

Palpitations are an abnormal awareness of one's heart beat. Palpitations can result from a cardiac arrhythmia, such as premature systole or paroxysmal tachycardia. Patients may describe palpitations by saying their hearts have "skipped a beat." Palpitations can also be associated with exercise, stimulants such as caffeine, and metabolic disturbances such as hyperthyroidism. It is important for the paramedic to determine onset, frequency, duration, previous episodes of palpitations, and the type of sensation the patient experiences, such as rapid beating, irregular beating, or forceful beating. Associated symptoms such as chest pain, dyspnea, or syncope can also be present.

## Past Medical History

After exploring the nature of the present illness, the paramedic should explore pertinent aspects of the patient's past medical history that may contribute to defining the problem. Four major factors should be considered when taking a past medical history: (1) current medications, (2) any present serious illness, (3) presence of cardiac risk factors, and (4) allergies.

It is important that the paramedic note all the medications a patient is taking, especially those medications that might contribute to defining the current problem. The paramedic should particularly note whether the patient takes any of the following medications:

- Nitroglycerin, a drug to relieve chest pain.
- Digitalis, a preparation such as digoxin that is often prescribed for congestive heart failure.
- Diuretic, a medication such as furosemide (Lasix), commonly prescribed for hypertension or congestive heart failure.
- Procainamide or quinidine, drugs that suppress chronic arrhythmias.
- Propranolol, a drug prescribed to relieve chest pain or to suppress chronic arrhythmias.

Is the patient currently under treatment for any serious illness, such as an infectious disease? Has the patient ever had any illnesses that are considered as cardiac risk factors? These conditions include hypertension, diabetes, previous heart attack or heart failure, rheumatic fever, or lung disease.

Does the patient have any allergies, especially drug allergies such as to Novocain? (Novocain is the numbing medication used in the dentist's office.) Novocain is related to lidocaine. Patients who have had an adverse reaction to Novocain may likewise have a reaction to lidocaine. It is essential to know if the patient is allergic to Novocain in case the patient develops arrhythmias that might necessitate the use of lidocaine.

## Physical Examination

The primary and secondary surveys of cardiac patients are similar to those for all patients. Certain parts of the physical examination, however, are emphasized in the patient with heart problems. The physical findings are then correlated with the patient's history to evaluate the current complaint.

As in the physical examination of every patient, the paramedic should first take the vital signs. A blood pressure reading over 140/90 indicates hypertension; however, in emergency situations, an elevated blood pressure may be due to anxiety. A systolic blood pressure of less than 90 mm Hg is usually an indication of serious hypotension and shock. The rate and quality of the pulse may give important clues to the critical nature of the patient's problem. Tachycardia may indicate anxiety, pain, congestive heart failure, or cardiac arrhythmia.

Pulse pressure (the difference between systolic pressure and diastolic pressure) indicates both stroke volume and arterial elasticity. In arteriosclerosis (hardening of the arteries), the arteries are more rigid and the pulse pressure is increased. In cardiogenic shock, the heart is unable to pump a normal stroke volume resulting in a fall in pulse pressure.

The patient's state of consciousness should also be checked because it indicates the adequacy of cerebral perfusion. Stupor or confusion often indicates inadequate cardiac output, which causes a reduction in cerebral perfusion. Skin color and temperature are important indicators of peripheral perfusion. The cold, sweaty skin of many patients with myocardial infarction signifies massive peripheral vasoconstriction.

The status of the patient's external jugular veins should also be checked during the head-to-toe survey. The neck veins provide an estimate of venous pressure in lieu of a central venous pressure line. Normally, when a patient is sitting or standing, the external jugular veins are collapsed above the suprasternal notch. Therefore, when a patient is sitting at a 45° angle, venous distention is not normally present. Elevated venous pressure is associated with congestive (right) heart failure, pericardial tamponade, tricuspid stenosis, and increased blood volume.

To estimate venous pressure, the paramedic should place the patient in a semisitting position at an angle of between 30° and 60° (usually at a 45° angle) with the head slightly rotated away from the external jugular vein being examined. The examiner should place the forefinger just above, and parallel to, the clavicle. The paramedic should place a finger inward to occlude the jugular vein, and wait 15 to 45 seconds for the vein to fill and become distended. The finger should then be released quickly and the height of the distended fluid column within the vein observed. Normally, this level, if visible, will be less than 3 cm above the sternal angle. When reporting the amount of neck vein distention, it is important that the paramedic specifies at what angle the patient was sitting.

The lungs must be auscultated for the presence of rales or wheezes that, if present, may indicate pulmonary edema as a result of left heart failure. Physical findings in pulmonary edema are discussed further in Module V.

To examine the heart, it is helpful for the paramedic to recall the location of the heart chambers and great vessels relative to the chest wall. The apex of the heart is in the fifth intercostal space slightly medial to the center of the clavicle; the base of the heart is at the level of the third costal cartilages. The inferior surface of the heart lies on the diaphragm.

Most of the anterior surface of the heart is formed by the right ventricle. The left ventricle lies to the left and behind the right ventricle. The right border of the heart is formed by the right atrium. The ascending aorta lies behind the sternum from the second through the fourth costal cartilages. The pulmonary artery lies slightly to the left of the ascending aorta; the superior vena cava lies to the right.

A complete examination of the heart is not adaptable to field use. Many such findings are esoteric and often paramedics do not have the proper equipment or must work in surroundings not conducive to performing a complete cardiac examination of inspection, palpation, and auscultation.

Abnormal vibrations from a diseased aortic valve and pulsations from an aortic aneurysm can be detected by palpation of the aortic area located in the second intercostal space to the right of the sternum. Pulmonary artery pulsations can be detected in the pulmonic area located in the second intercostal space to the left of the sternum. Left ventricular contraction normally produces a visible and palpable impulse at the apex located in the fifth intercostal space, medial to the left midclavicular line.

To auscultate the heart, both the diaphragm and bell of the stethoscope should be used. The environment must be as quiet as possible for auscultation to be done correctly. However, since a more sophisticated cardiac auscultation can be conducted under more favorable conditions in the hospital, only a general discussion of heart sounds follows.

Prior to listening for heart sounds, the paramedic should identify the heart rate and heart rhythm at the apex. Since the apical pulse represents the contraction of the left ventricle, it is the best source for determining heart rate. Normally, the apical pulse is the same as the radial pulse. However, if the patient has a trachyarrhythmia, there may be a difference between the radial and apical pulse. This is known as pulse deficit.

Heart sounds are produced by the closure of the heart valves during a cardiac cycle. Audibility of heart sounds varies with the position of the stethoscope and the size of the chest wall. Heart sounds may be inaudible in obese, heavy-chested individuals, and quite loud in thin-chested patients.

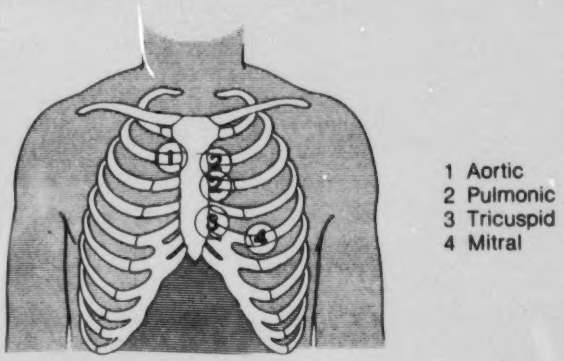


**Figure 16. Four Sites for Cardiac Auscultation**

Four main topographic areas are used in cardiac auscultation—the aortic, pulmonic, and mitral areas, as described above, as well as the tricuspid area, which is in the first intercostal space at the left of the sternum. These areas do not correspond to the anatomic locations of the valves, but are sites at which the particular valve is heard best (see Fig. 6.16).

The first heart sound ($S_1$) is the systole, or "lub," and represents the closure of the mitral and tricuspid valves. The second heart sound ($S_2$), or "dub," is the diastole and represents the closure of the aortic and pulmonic valves. Normally, diastole is longer than systole.

Sometimes, a third heart sound ($S_3$) may be heard approximately one-third through diastole and will produce a rhythm that sounds like:

"Ken — tuc' — ky, Ken — tuc' — ky"
($S_1$) — ($S_2$) — ($S_3$) ($S_1$) — ($S_2$) — ($S_3$)

A third heart sound is normal in children and young adults before age 30. Beyond age 30, an $S_3$ often indicates the presence of congestive heart failure. If, during auscultation of the lungs, rales or wheezes are heard, auscultation of the heart for the presence of an $S_3$ could aid in confirming the finding of congestive heart failure.

If a suspected cardiac patient presents with signs of congestive heart failure—rales, distended neck veins, and/or an $S_3$—the lower back (sacrum) and the legs should also be checked for the presence of edema.

To evaluate the integrity of the vascular system, the carotid, brachial, radial, femoral, popliteal, and dorsalis pedis pulses should be palpated. The strength of these pulses should be noted as well as whether they are equal on both sides. An absent pulse at any one of these sites may indicate that the patient is severely hypotensive, or that the artery is occluded.

If the patient is not hypotensive and one of the pulses cannot be palpated, the extremity must be checked for signs of arterial occlusion. Classic signs of arterial occlusion are the "5 P's": pain, paralysis, paresthesia (an abnormal sensation as burning, prickling, or numbness), pulselessness, and pallor. In 50 percent of these patients, pain is not the presenting symptom, but the extremity will feel cold or numb to the touch. The extremity will also appear pale or cyanotic. The pulse is absent or diminished in strength below the level of occlusion. Without treatment, 50 percent of these patients will develop gangrene, which will necessitate amputation of the affected extremity. Approximately 40 percent of these patients will die if sudden arterial occlusion is left untreated.

## Unit 3. Pathophsyiology and Management of Cardiovascular Problems

The pathophysiology and management of eight cardiovascular problems are discussed in this section. These problems include coronary artery disease, angina, acute myocardial infarction, congestive heart failure, cardiogenic shock, syncope, myocardial trauma, and hypertensive emergencies.

### Coronary Artery Disease and Angina

The coronary arteries are blood vessels that supply the heart with nutrients and oxygen. When a coronary artery becomes blocked, the heart muscle it supplies is rapidly deprived of oxygen. If oxygen deprivation remains uncorrected, the heart muscle will die.

Arteriosclerosis is a degenerative disease that hardens and narrows arteries. A common type of arteriosclerosis, intimal atherosclerosis, is particularly important because it involves the aorta and the cerebral and coronary arteries. Coronary arteries are especially prone to atherosclerosis. Turbulent blood flow and numerous bends contribute to thickening and loss of elasticity in the arterial walls. These conditions result in narrowing of the arteries and a reduction in arterial blood flow (see Fig. 6.17).

Approximately 4 to 5 million Americans have coronary artery disease, and more than half a million of these die each year from it.

Certain factors increase an individual's risk of developing atherosclerotic lesions that will lead to coronary artery disease. These risk factors include:

- Hypertension.
- Cigarette smoking.
- Diabetes.
- Elevated serum cholesterol.
- Sedentary lifestyle.
- Dietary habits (excessive intake of calories, carbohydrates, and/or saturated fats).
- Obesity.
- Sex (male).
- Family history.
- Aggressive, competitive personality (so-called type-A personality).

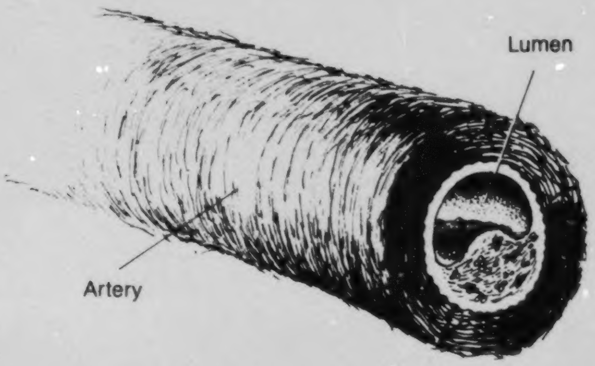


**Figure 17. Atherosclerosis**

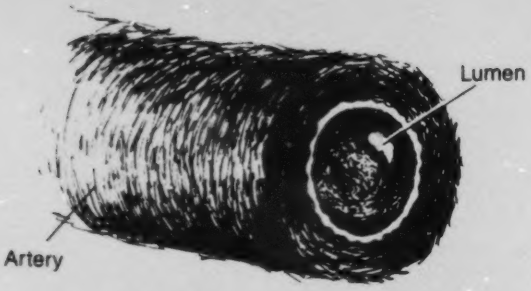


Figure 18. Results of Atherosclerosis

- Stressful occupation or environment.
- Use of birth control pills.

Atherosclerosis is a gradual process involving obstruction and hardening of the arterial wall. In the beginning, small cholesterol and lipid (fat) deposits form on the intima, usually in an area where platelets have attached or a blood clot was formed. These deposits enlarge and irritate the arterial wall. The artery reacts to this irritation by swelling and growing new capillaries. Scar formation (fibrosis) follows and a calcification process begins. During the inflammatory state, capillaries may rupture and bleed into the arterial wall. This produces blood clots, which further narrow the lumen and critically reduce arterial blood flow. Eventually, the intima becomes thickened, hardened, and inelastic (see Fig. 6.18).

As portions of a coronary artery become obstructed, other vascular pathways enlarge. These vascular pathways are identified as the collateral coronary circulation. The collateral arteries serve as an alternative route for blood flow around the obstructed artery to the myocardium.

Patients in the early stages of atherosclerosis may be asymptomatic and may continue so for many years. However, when atherosclerosis has progressed to the point that coronary blood flow can no longer meet the oxygen demands of the myocardium, pain will result. The principal symptom of coronary artery disease is angina pectoris, which literally means "choking in the chest". Angina occurs when there is a discrepancy between the oxygen requirements and the oxygen supply to the myocardium. The myocardium, consequently, becomes ischemic, and lactic acid and carbon dioxide accumulate. The concept of supply and demand is important in this context. The individual at rest may have an adequate supply of oxygen to the heart in spite of narrowed coronary arteries; however, when the individual exercises or experiences some other physical or emotional stress, blood flow to the heart cannot meet its increased oxygen demand, and angina results. The patient who experiences angina at rest, when oxygen needs are minimal, has much more severe coronary artery disease than the patient who experiences angina only with vigorous exercise.

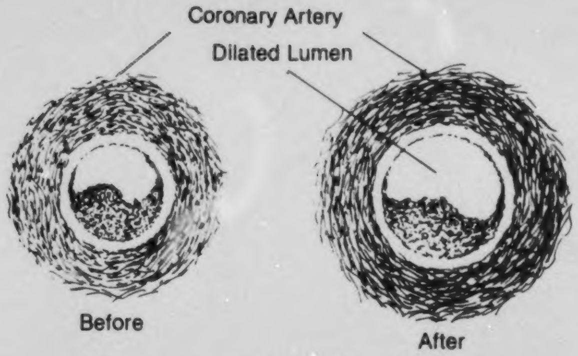


Figure 19. Effects of Nitroglycerin

Angina pectoris is variable in its presentation, but is classically characterized as substernal chest pain that may be pressing, tight, or squeezing. Anginal pain may radiate to either shoulder and arm, but most commonly radiates to the left shoulder and the left arm. Pain may also radiate to the neck jaw and teeth, upper back, or epigastrium. Angina is not influenced by respiration, coughing, or changes in body movement. Angina usually lasts 3 to 5 minutes and is transient in nature. The condition can be relieved by stopping the precipitating stress factor or through use of the drug nitroglycerin. Nitroglycerin acts by causing peripheral vasodilation, which reduces myocardial workload and myocardial oxygen demand (see Fig. 6.19).

It is important for the paramedic to distinguish between stable and unstable angina. Stable angina follows a recurrent, predictable pattern. The individual experiences pain after a certain amount of physical exertion, such as climbing a flight of stairs, or after situations with some amount of emotional impact. The pain produced also has a predictable location, intensity, and duration. The patient with stable angina may state, "Every time I walk to the bus stop, I get a squeezing pain under my breastbone and I have to sit down for 2 or 3 minutes until it goes away."

Unstable angina ("preinfarction angina") is much more ominous than stable angina, and indicates further coronary artery obstruction. Unstable angina is characterized by a change in the frequency, intensity, and/or duration of the pain and often occurs without a precipitating stress. The patient may state that over the past several days or weeks the anginal attacks have grown more frequent or more severe, or that they occur during rest. Unstable angina is a warning of impending mycardial infarction.

## Acute Myocardial Infarction

Acute myocardial infarction (AMI) ("heart attack") occurs when part of the cardiac muscle is deprived of an adequate supply of blood long enough so that the muscle dies (necrosis). Many factors can acutely decrease flow through coronary vessels already narrowed by atherosclerosis.

The precipitating factors of any acute myocardial infarction include occlusion of a coronary artery by a blood clot (thrombus) and conditions that reduce blood flow throughout the body (shock, dysrhythmias, pulmonary embolism, etc.).

AMI is the leading cause of death in the United States today. There are more than half a million deaths from AMI in this country each year. Of those deaths, more than half occur during the first 2 to 3 hours outside the hospital. Ninety percent of deaths from AMI are caused by arrhythmias, usually ventricular fibrillation, that occur during the early hours of the infarct and that can be prevented or treated. Many deaths from acute myocardial infarction are preventable. The availability of advanced life support in a community will be a major factor in preventing the tragic, unnecessary loss of life associated with AMI.

The most important symptom of AMI is chest pain, which occurs in 80 to 90 percent of the patients with the disorder. The pain is similar to that of angina, but is more intense, lasts longer (30 minutes to several hours), and is unrelieved with nitroglycerin. It is classically described as severe—"heavy," "squeezing," "crushing," or "tight." Often a patient will use a clenched fist to describe the pain. In approximately 25 percent of patients, the pain will radiate to the arms, most often the left arm, and into the fingers; less commonly, the pain will radiate to the neck, jaw, upper back, or epigastrium. Occasionally, an AMI is mistaken by the patient for indigestion. Like angina, the pain of AMI is not influenced by coughing, deep breathing, or other body movements. The condition may occur at rest or after a heavy meal. The patient with AMI may have a history of angina, thus, angina must be a warning of a possible future AMI. Table 6.2 illustrates the differences between the pain of angina and the pain of AMI.

Approximately 10 to 20 percent of patients with AMI do not experience chest pain. This is commonly known as a "silent" AMI. The incidence of painless AMI rises sharply with age; in the elderly patient, AMI may present instead with sudden shortness of breath progressing to pulmonary edema, sudden loss of consciousness, unexplained drop in blood pressure, apparent stroke, or confusion. Other symptoms commonly associated with AMI are diaphoresis (profuse sweating), dyspnea, nausea, vomiting, extreme weakness or fatigue, dizziness, and palpitations.

The physical findings of AMI may be few and will vary with the site and extent of cardiac muscle damage and the amount of sympathetic nervous system response. Therefore, diagnosis in the field will depend primarily on the history of the current complaint. Treatment and stabilization should be started immediately in any middle-aged patient who complains of chest pain. A detailed history and physical examination should be given second priority.

## Table 6.2

**Signs and Symptoms of Angina Pectoris and Acute Myocardial Infarction**

| Presenting Signs and Symptoms | Angina Pectoris | Acute Myocardial Infarction |
|---|---|---|
| Pain | | |
| Intensity | Mild to moderate... | Very severe, intense. |
| Duration | 3 to 5 minutes ........ | 30 minutes to several hours. |
| Precipitating factors | Specific, predictable physical or emotional stress. | No specific predictable factor. |
| Relieving factors | Rest ........................<br>Nitroglycerin ......... | None. |
| Associated symptoms | May be none .......... | Diaphoresis, Nausea and vomiting, Fear of impending doom. |

The patient with AMI usually appears anxious or frightened. If the patient is hypoxic, he or she may also appear confused, irritable, or restless. The skin may be pale, cold, or clammy. Blood pressure may be normal, low (systolic pressure of 90 mm Hg or less) if the cardiac output is below normal, or elevated (greater than 140 mm Hg systolic or 90 mm Hg diastolic) in response to stimulation of the sympathetic nervous system. Likewise, the pulse may be normal, bradycardic (slow) if the parasympathetic nervous system is dominant, or tachycardic (fast) if the sympathetic nervous system is dominant.

Advanced life support (definitive cardiac care) must be initiated immediately on all patients who are suspected of having AMI. It is important for paramedics to remember that more than half the deaths from myocardial infarction occur within the first few hours and that patients often do not call for help until several hours after the pain begins. Early treatment can mean the difference between life and death in an otherwise healthy and relatively young man or woman.

Management of the uncomplicated AMI consists of the following definitive cardiac care procedures. The paramedic should:

- Attach monitoring electrodes. Transmit the rhythm strip to the hospital for evaluation if biotelemetry is available.
- Immediately administer oxygen by mask or nasal cannula at a flow rate of 4 to 6 L/min. (If an oxygen reservoir mark is used, flow rate must be

high enough to keep reservoir filled.) Since oxygen therapy can assist in reducing the incidence of arrhythmias following AMI, it should never be withheld from any patient suspected of the condition. The patient with chronic obstructive pulmonary disease should also receive oxygen, but at a lower flow rate. If this patient's respirations become depressed, ventilations can be assisted.

- Initiate an intravenous (I.V.) line of 5-percent dextrose in water (D5W) using a 250-cubic centimeter (cc) bag and microdrip set. The I.V. rate should be regulated just enough to keep the vein open, usually between 20 to 30 microdrops per minute.
- Relief of pain should be given a high priority. Sublingual nitroglycerin should be administered in normotensive or hypertensive patients. If this therapy is unsuccessful, 2 to 5 mg doses at 5 minute intervals upon an order from a physician.
- The use of lidocaine as prophylactic antiarrhythmic therapy may be ordered by the physician. This use has been shown in some studies to significantly reduce the incidence of primary ventricular fibrillation.
- Obtain a more detailed history and perform a physical examination after initial stabilization.
- Transport the patient in a comfortable position, usually semisitting.

Following AMI, the patient's clinical course can take several directions. After hospitalization, the patient's course may remain uncomplicated and the infarcted area may heal. During the first few hours of AMI, arrhythmias may develop. Approximately 70 percent of patients with AMI will develop a ventricular arrhythmia. If a large area of cardiac muscle is infarcted, the pumping ability of the heart can be severely impaired and congestive heart failure will ensue. If more than 50 percent of the left ventricle is lost due to infarction, cardiogenic shock will occur.

## Congestive Heart Failure

Heart failure following AMI can be understood as mechanical pump failure, or the inability of the heart to maintain cardiac output adequate to meet the metabolic demands of the body. Congestive heart failure indicates circulatory overload either in the systemic circulation, or in the pulmonary circulation, due to an ineffective pump. As a result there are two types of heart failure: left heart failure (acute pulmonary edema) and right heart failure (chronic congestive heart failure).

In AMI, the primary insult is to the left ventricle, affecting the ability of the ventricle to pump blood effectively. Since the heart is a two-pump system, if the pumping ability of the right ventricle is not comprised as a result of the AMI, a temporary imbalance in the cardiac outputs from both ventricles results. The right heart continues to pump blood as usual; however, the left ventricle is unable to completely eject the blood delivered to it into the systemic circulation. As a result, blood begins to back up behind the left ventricle causing an increase in the pressure in the left atrium and pulmonary vessels; this allows blood to accumulate in the lungs. As the pulmonary blood vessels become increasingly engorged with blood, serum is forced out of the capillaries into the alveolar spaces. The serum mixes with air in the alveolar spaces to produce a foam (pulmonary edema). Because the alveoli are partly filled with fluid, the amount of lung tissue available for gas exchange is greatly reduced, and oxygenation is impaired.

In the early stages of pulmonary edema, the patient may appear restless, because the hypoxia results from impaired oxygenation. As left heart failure progresses, wheezes and an $S_3$ are present. The patient experiences increasing difficulty in breathing and must literally sit up to breathe (orthopnea). To compensate for the increasing hypoxia, the cardiovascular centers in the brain stimulate the sympathetic nervous system, which produces tachycardia, tachypnea, and increased peripheral vascular resistance. If these compensatory mechanisms fail, hypotension occurs, rales develop, and the patient develops a productive cough of blood-tinged frothy sputum. As the accumulation of pulmonary fluid progresses, hypoxia may become so severe that the patient becomes cyanotic and the state of consciousness decreases. Patients may be literally drowning in their own secretions. This situation is life threatening and demands immediate emergency intervention (see Fig. 6.20).

Treatment of left heart failure (pulmonary edema) is aimed at improving oxygenation, increasing myocardi-

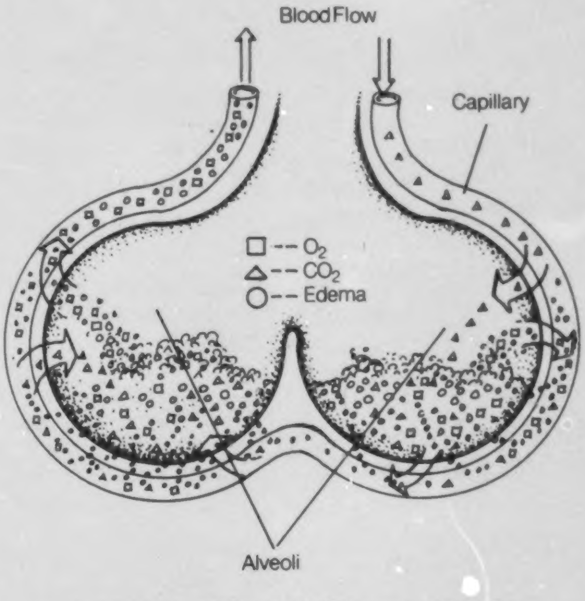


**Figure 20. Effects of Pulmonary Edema**

al contractility, and reducing venous return. Management of left heart failure consists of the following definitive procedures. The paramedic should:

- Sit the patient up with the feet dangling. This position is the most comfortable for the patient and is advantageous, because it decreases venous return to the heart. The actual work of breathing is thus decreased.
- Administer high-flow oxygen by mask (8–10 L/min). Occasionally acute pulmonary edema is so severe that respiratory failure occurs. If this happens, intubation and mechanical ventilation are necessary. Positive pressure ventilation via an oxygen-breathing device such as an Elder valve increases the alveolar pressure and diameter. Alveolar collapse is then reduced and ventilation is improved. In addition, venous return is decreased as a result of the increase in intrathoracic pressure.
- Initiate an I.V. with D5W to keep open.
- Apply monitoring electrodes. Because hypoxia and metabolic acidosis accompany acute pulmonary edema, these patients are predisposed to arrhythmias.

The following drugs may be ordered:

- Morphine sulfate. Morphine is a mainstay in the management of acute pulmonary edema because of its vasodilation, analgesic, and sedative effects. It is recommended that initially a small dose of 4 to 5 milligrams (mg) be given I.V. If substantial improvement has not occurred and hypotension has also not occurred, morphine can be repeated in increments until the symptoms of acute respiratory distress are relieved.
- Aminophylline. Aminophylline can be beneficial in the treatment of acute pulmonary edema by causing bronchodilation and increasing cardiac output. Add 200 to 500 mg of aminophylline to 100–cc D5W and infuse at a rate of 20 mg/minute.
- Furosemide (Lasix). Furosemide is a potent, rapid-acting diuretic given I.V. to decrease intravascular volume. Action begins within 5 to 15 minutes following the injection. Dosage ranges from 200 to 80 mg I.V. push.
- Digoxin. Digoxin is used on a limited basis as an adjunct to oxygen, morphine, and furosemide when acute pulmonary edema is a result of atrial fibrillation with rapid ventricular response. Digoxin serves to increase contractility of the heart. Where prolonged transport is necessary, digoxin 0.5 to 0.75 mg may be given slowly I.V.

Rotating tourniquets can also be employed using the following guidelines:

- Apply tourniquets to three of the four extremities as proximal to the torso as possible.
- Apply tourniquets tightly enough to obstruct venous return but not arterial blood flow.
- Check for presence of distal pulses after each tourniquet is applied.
- Every 10 minutes, remove a tourniquet from one extremity and secure it to a free extremity. The I.V. arm may be used if a superficial vein, such as a hand vein, has not been used.
- Rotate the tourniquets in a clockwise direction.

The paramedic should then transport the patient. Monitor vital signs every 5 minutes.

Usually, right heart failure follows left heart failure. As blood backs up from the heart into the lungs, the right side of the heart must work harder to pump blood into the already engorged pulmonary vessels. Eventually the right heart can no longer keep up with the increased workload and fails. When right heart failure occurs, blood backs up behind the right ventricle and increases the pressure in both the right atrium and the systemic veins.

As a direct result of right heart failure, venous return is impeded, and organs become congested. This is manifested by distented jugular veins and the development of body edema (see Fig. 6.21). The increased

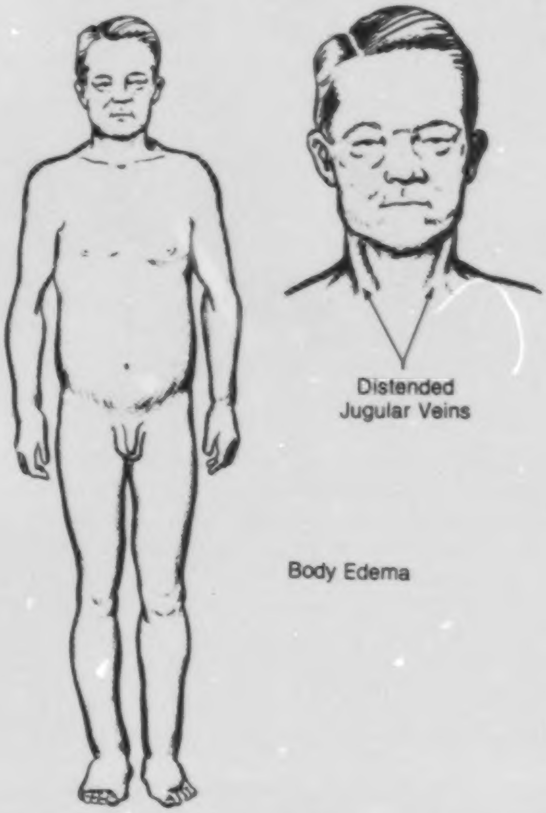


**Figure 21. Patient with Body Edema and Distended Jugular Veins**

## Table 6.3

### Treatment of Acute Pulmonary Edema

| Therapeutic Goal | Therapy | Principle | Precaution |
|---|---|---|---|
| Improvement in oxygenation. | Patient sits up | Decreases work of breathing and venous insert. | Use position cautiously if hypotension is present. |
| | High flow oxygen | Reverse hypoxemia and prevent metabolic acidosis. | Oxygen mask may be frightening to "suffocating" patient. |
| | Positive-pressure ventilation. | Decreases fluid and collapse; decreases venous return. | |
| | Aminophylline | Bronchodilator | Will cause hypotension and ventricular arrhythmias if given rapidly. |
| Reduction of venous return. | Morphine sulphate | Causes vasodilation and reduces venous return; decreases anxiety. | May cause hypotension and respiratory depression; monitor vital signs. |
| | Furosemide | Rapid diuresis | If given in excessive amounts, can result in hypotension and electrolyte depletion; monitor vital signs. |
| | Rotating tourniquets | Causes venous pooling in extremities. | May be uncomfortable; when using tourniquets, remove one at a time at 10-minute intervals to avoid over-loading pulmonary circulation again. |
| Increase in myocardial contractility. | Digoxin | Increases force of contraction. | Monitor for arrhythmias. |

venous pressure forces serum through the capillary walls into the subcutaneous tissues, producing pitting edema. (The existence of this type of edema is confirmed by the pit that forms when pressure is applied.) In ambulatory or walking patients, edema usually first occurs in the dependent parts of the body—the hands and feet—then over the entire body (anasarca). Edema may also be present in the presacral region in recumbent or resting patients.

Increased pressure in the hepatic veins results in liver engorgement, causing the liver to become enlarged and tender. As venous congestion becomes severe, serum may be forced into the abdomen (ascites), pleural cavity (pleural effusion), and pericardial cavity (pericardial effusion).

The development of right heart failure can actually improve left heart failure. Because the right heart is unable to pump blood to the lungs efficiently, pulmonary congestion may actually decrease—thus improving the symptoms of dyspnea or heart failure.

Treatment and management of the patient in congestive heart failure are aimed at decreasing intravascular volume and correcting hypoxia. The paramedic should, first, sit the patient up and administer oxygen. The patient's heart rate should be monitored, because monitoring is indicated in any patient with significant cardiac disease. If signs of left heart failure are present, the patient should be treated as in pulmonary edema (see Table 6.3).

## Cardiogenic Shock

When the heart is damaged so badly that it can no longer pump enough blood to maintain adequate tissue perfusion, cardiogenic shock occurs. Cardiogenic shock indicates extensive damage to the myocardium and has a mortality rate of approximately 85 percent.

The signs and symptoms of cardiogenic shock are the same as those found in other types of shock, which are described in greater detail in Module II. The clinical picture is characterized by (1) signs of inadequate tissue perfusion such as pallor; cool, clammy skin; mental confusion; restlessness; and cyanosis of varying degrees and (2) a systolic blood pressure of less than 80 mm Hg. A note of caution: Patients with preexisting hypertension may be in shock although their systolic blood pressure may be higher than 80 mm Hg.

Treatment of cardiogenic shock is aimed at improving peripheral tissue perfusion and increasing myocardial contractility without increasing cardiac work (see Table 6.4). Management of cardiogenic shock consists of the following definitive procedures. The paramedic should:

- Place the patient supine with 30° elevation of the lower extremities. The Trendelenburg position is not recommended for treating cardiogenic shock.
- Administer high-flow oxygen by mask. Endotracheal intubation may be necessary if the patient becomes unresponsive.
- Start an I.V. with D5W to keep the vein open.
- Administer the following drugs, if ordered by the physician:
  —Sodium bicarbonate. Sodium bicarbonate may be ordered to combat metabolic acidosis caused by poor tissue oxygenation.
  —Norepinephrine (Levophed). Norepinephrine is an alpha stimulator and may be ordered to increase arterial blood pressure. Add 2 mg norepinephrine to 250 cc D5W and infuse I.V. piggyback via a microdrop administration set at a rate of 30 to 60 microdrops per minute—2 to 4 micrograms (mg) per minute. Titrate flow to the blood pressure response. Norepinephrine must be administered in a large vein, because tissue necrosis will occur if the I.V. infiltrates.
  —Dopamine (Intropin). Dopamine is a vasopressor that stimulates both alpha and beta receptors. Dopamine increases myocardial contractility and, thus, cardiac output. Dopamine also produces mild vasoconstriction to increase arterial blood pressure. Dopamine has the additional action of

### Table 6.4

**Treatment of Cardiogenic Shock**

| Therapeutic Goal | Therapy | Principle | Precaution |
|---|---|---|---|
| Correct peripheral pooling of blood. | Elevate lower extremities 30 degrees. | Increase venous return | Do not use Trendelenburg position. |
| Correct hypoxia | High flow oxygen<br>Endotracheal intubation. | | |
| Correct acidosis | Sodium bicarbonate | To correct acidosis produced by inadequate tissue perfusion. | Do not produce sodium overload. |
| Improve circulation | Norepinephrine | Alpha stimulation; increases peripheral vascular resistance; cardiac output remains unchanged. | Monitor blood pressure frequently; blood pressure usually raised to 90 mm Hg systolic.<br>Observe site of administration carefully; infiltration will cause local tissue necrosis. |
| | Dopamine | Alpha-stimulator produces vasoconstriction to increase blood pressure. Beta-stimulator increases cardiac contractility, increases cardiac output. | Monitor blood pressure frequently and titrate to blood pressure response; may produce ventricular arrhythmias. |

dilating the mesenteric and renal vessels to increase blood flow and diuresis. Add 1 ampule (200 mg) of dopamine to 250 cc D5W (3 mg/cc) and infuse at 2 to 5 mg per kilogram (kg) per minute. Titrate the rate to the blood pressure response.

—Methylprednisolone (Solu-Medrol). Although the effectiveness of methylprednisolone in cardiogenic shock is unproven, a dose of 3–50 mg/kg may be given slowly I.V. push.

## Syncope

Syncope, or fainting, is a sudden, temporary loss of consciousness caused by inadequate cerebral blood flow. Although syncope may result from different underlying problems, the most significant causes are cardiac related.

Simple syncope, or vasovagal syncope, is the most common type of syncope and can occur in healthy individuals. Syncope usually follows some emotional stress such as pain, fright, or the sight of blood. This stress produces reflex peripheral vasodilation and, consequently, pooling of blood in the extremities.

Simple syncope usually occurs when the patient is sitting or standing; consciousness rapidly returns when the patient becomes horizontal. However, the patient may faint again if he or she tries to sit or stand too quickly. The simple faint may occur without warning or may be preceded by a brief period of symptoms such as pallor, weakness, cold sweating, nausea, abdominal discomfort, or blurred vision. Preceding the faint, a tachycardia may be present; however, during the faint, the pulse usually slows to 50 or less.

Syncope of cardiac origin can occur in any position. Syncope that occurs when the patient is lying down is almost always of cardiac origin and indicates a transient decrease in cardiac output. The decrease in cardiac output may be caused by bradyarrhythmias, tachyarrhythmias, valvular lesions that obstruct blood flow, or heart block.

Postural syncope occurs when the patient sits or stands up from a supine position. The causes of postural syncope include drugs, chronic disease, and prolonged standing in hot weather.

Carotid sinus syncope is also very common. An individual with a sensitive carotid sinus may faint when the carotid sinus is compressed.

The vagus nerve is stimulated, which slows the heart rate and produces hypotension. These effects combine to produce a faint. The syncopal episode can occur in men while they are shaving and can also be precipitated by the constriction of a tight collar. Patients may also faint after other actions that result in vagal discharge such as violent coughing, laughter, or urination. There are often no warning symptoms.

In taking a history from a patient who has experienced a syncopal episode, the paramedic should find answers to the following questions:

- In what position was the patient when fainting occurred?
- Were there any warning symptoms preceding the faint?
- Did some stressful event precede the faint?
- Has the patient ever fainted before, and if so, under what circumstances?
- Does the patient have a history of cardiac disease?
- Does the patient take any medication?

Regardless of the cause of syncopal episode, there are basic management principles that apply forms of syncope. The paramedic should:

- Place the patients supine where they have fallen. The supine position increases cerebral blood perfusion. If patients are placed in a sitting position, they may faint again because of decreased cerebral blood flow. If patients regain consciousness, discourage them from sitting up or standing. Patients should be transported supine to the hospital.
- Establish an airway and administer oxygen.
- Loosen any tight clothing.
- Elevate the lower extremities for 10 to 20 seconds to increase venous return.
- Apply monitoring electrodes to determine the presence of an arrhythmia.
- Initiate an I.V. of 250 cc D5W to keep open.
- Monitor vital signs.

## Other Complications of AMI

Other complications of AMI are ventricular aneurysm and cardiac rupture. Ventricular aneurysm may develop as a result of myocardial infarction. A ventricular aneurysm is a thin-walled bulge in the necrotic area in the wall of the left ventricle. When the ventricle contracts, the aneurysm balloons out; some of the blood pumped into the ventricle flows into the balloon and is not entirely ejected. If the aneurysm occupies 25 percent or more of the ventricular wall, the ventricle pumps even less effectively and congestive heart failure results (see Fig. 6.22)

Cardiac rupture may also occur in an infarcted area, but fortunately, this complication is relatively uncommon. Cardiac rupture, in a majority of instances, occurs on the third or fourth day after infarction. The left ventricular wall, papillary muscle, or interventricular septum may rupture following AMI. If the left ventricle ruptures, blood escapes into the pericardial

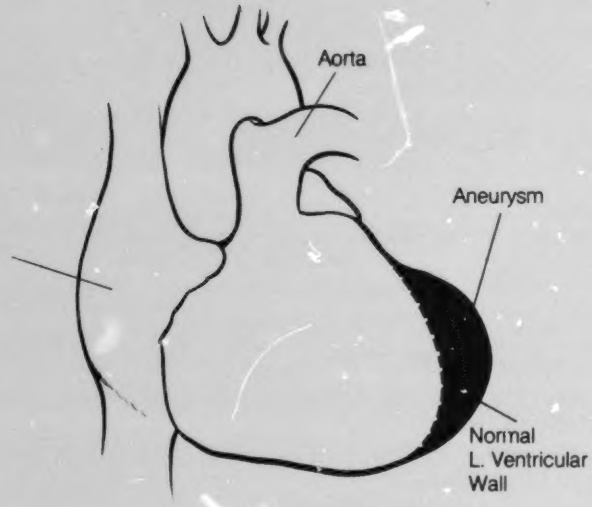


Figure 22. Aneurysm on the Ventricular Wall

sac producing cardiac tamponade. This complication is usually manifested by the acute onset of shock, jugular venous distention, sinus bradycardia, and, ultimately, electromechanical dissociation. Death can occur within 15 minutes unless the tamponade is relieved and the rupture is repaired surgically (see Fig. 6.23).

Rupture of the papillary muscle leads to acute mitral insufficiency and produces profound congestive heart failure, shock, and death. Rupture of the interventricular septum results in severe depression of the left ventricle and pulmonary edema that is resistant to therapy. Hypotension and death ultimately result (see Fig. 6.24).

## Myocardial Trauma

One frequently overlooked complication of blunt chest injury is trauma to the heart and great vessels. Although the heart is fairly resilient, its position behind the sternum makes it vulnerable to blunt impact injuries. Blunt chest trauma most commonly occurs in steering wheel injuries. Myocardial contusions have occurred in automobile collisions at speeds as low as 25 miles per hour. Myocardial injury may even occur with abdominal trauma.

Myocardial injuries tend to be missed, because there are often few signs or symptoms of cardiovascular problems on the initial examination. However, the various injuries produced by nonpenetrating injuries can be serious. All patients with major chest wall trauma should be treated as if they have myocardial trauma until it is proven that they do not.

Automobile accidents are the main cause of myocardial trauma. It is important that the paramedic determine how fast the vehicle was moving, with what did the vehicle collide, and the direction of impact. Frontal impact injuries are particularly dangerous, because the impact depresses the posterior sternum, which compresses the heart. Major complications of myocardial trauma are myocardial contusion and cardiac tamponade.

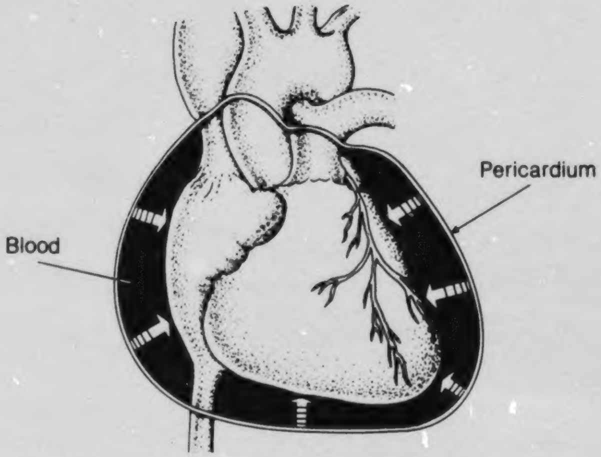


Figure 23. Cardian Tamponade

Myocardial contusion is often asymptomatic and masked by symptoms of associated injuries. For example, since the cardiac muscle is damaged and necrosis does occur, myocardial contusion can simulate the signs, symptoms, and complications of AMI.

Primary problems associated with myocardial contusion are cardiac arrhythmias and conduction abnormalities. The site of injury influences the type of arrhythmia encountered. Right-sided chest trauma fre-

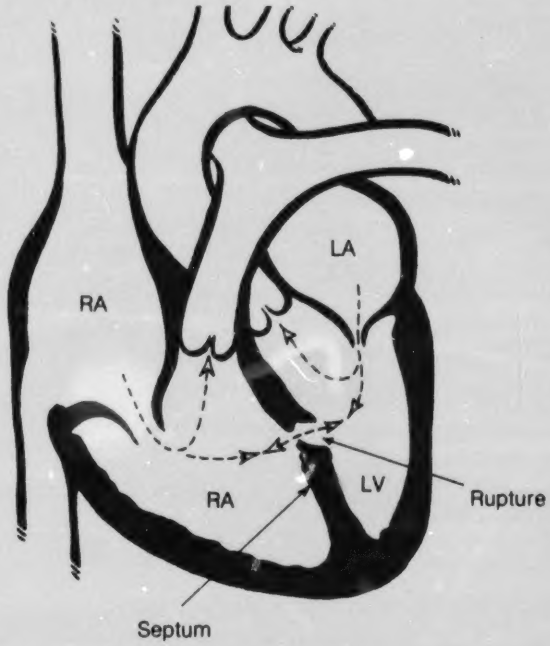


Figure 24. Rupture of the Interventricular Septum

quently results in atrial arrhythmias and heart block. Left-sided injuries are more likely to result in ventricular fibrillation. Ventricular arrhythmias are treated as if they occurred during AMI (see above); lidocaine is used to control premature ventricular contractions and countershock is used to control ventricular fibrillation.

An accumulation of blood in the pericardial sac is called cardiac tamponade. Tamponade can be caused by severe myocardial contusion or a tear in a great vessel at the point where it leaves the pericardial sac. When blood fills the pericardial sac, the heart is unable to fill completely, and cardiac output is reduced. As a result, atrial pressure falls and venous pressure rises. Jugular neck vein distention is also present. Pulse pressure (the difference between systolic and diastolic pressure) narrows as the stroke volume falls. Shock is frequently far greater than expected from the amount of blood lost. Blood in the pericardial sac muffles the heart sounds, which will sound more distant upon auscultation.

Cardiac tamponade is a dire emergency Tamponade must be rapidly treated by removing blood from the pericardial sac (pericardiocentesis). This procedure should be performed in the emergency department under controlled conditions. Therefore, a patient suspected of having a cardiac tamponade must be transported immediately to the hospital. If the patient is unconscious and pulseless, the paramedic should begin cardiopulmonary resuscitation.

### Hypertensive Emergencies

Approximately 21 million Americans are afflicted with hypertension (high blood pressure). Hypertension is responsible for more than 20,000 deaths in this country annually. In addition, hypertension is a major risk factor for AMI and cerebrovascular accident (stroke).

Hypertension is usually defined as a resting blood pressure in excess of 140/90 mm Hg. Anxiety, emotional stress, pain, and physical exercise can cause a transient elevation of the blood pressure level, but a persistent elevation of the diastolic pressure indicates hypertensive disease. Left untreated, hypertension significantly shortens life span and leads to other medical problems.

When the arterial blood pressure rises abruptly to a level of greater than 200/130 mm Hg and persists for a prolonged period, a hypertensive crisis is said to be present. A hypertensive crisis imminently threatens the integrity of the patient's cerebral and cardiovascular systems. Frequently, but not always, an acute hypertensive crisis is accompanied by severe headache, irritability, nausea, and vomiting. These symptoms are followed by confusion, convulsions, and coma. Acute hypertensive crises may be complicated by acute pulmonary edema or by intracranial hemmorrhage. In such cases, it is essential that the blood pressure be reduced promptly under controlled conditions in the hospital. In the field, only supportive measures are feasible. To support the patient in the field, the paramedic should:

- Secure an airway and administer oxygen.
- Initiate an I.V. with D5W to keep open.
- Apply monitoring electrodes.
- Monitor vital signs every 5 minutes.
- Transport the patient to the hospital.

## Unit 4. Reading and Understanding a Normal EKG

Fundamental information on reading and understanding an EKG is discussed in this unit including electrophysiology, components of the EKG record, and interpreting the EKG strip.

### Electrophysiology

Each living cell of the body that has the capacity to react to a stimulus is said to be resting or polarized. The inside of the resting cell is electronegative in comparison to the outside of the cell, which is electropositive. This difference can be attributed to the intracellular and extracellular concentration of electrolytes. The semipermeable cell membrane is the main regulator of the resting or polarized state.

When a cell is stimulated to contract, the depolarization process begins. The cell membrane becomes more permeable to extracellular electrolytes, and a shift in electrical charges occurs. The inside of the cell thus becomes electropositive and the outside, electronegative. The wave of depolarization moves across the cell causing the cell to contract. After contraction, a negatively charged wave spreads through the fiber and returns the cell to its original electronegative state. The return of the cell to its resting state is called repolarization. The cell is again polarized and may be stimulated again. (For more details, see Unit 1 of this Module.)

All cells of the body—except cardiac cells—require a stimulus to depolarize. The specialized cardiac cells possess the property of automaticity—that is, they can spontaneously depolarize or contract. If the depolarization of one cell is strong enough, it can influence the contraction of the adjacent cells. Why, then, does the heart beat rhythmically instead of chaotically? The answer is that not all cardiac cells depolarize or contract at the same time (see Fig. 6.25).

Normally, the cells of the SA node depolarize faster than any other cells of the heart—at a rate of 60 to 100 times per minute. The SA nodal cells stimulate the other cells of the conduction system in an organized manner. Thus, because the SA nodal cells depolarize faster, the SA node becomes the pacemaker of the heart.

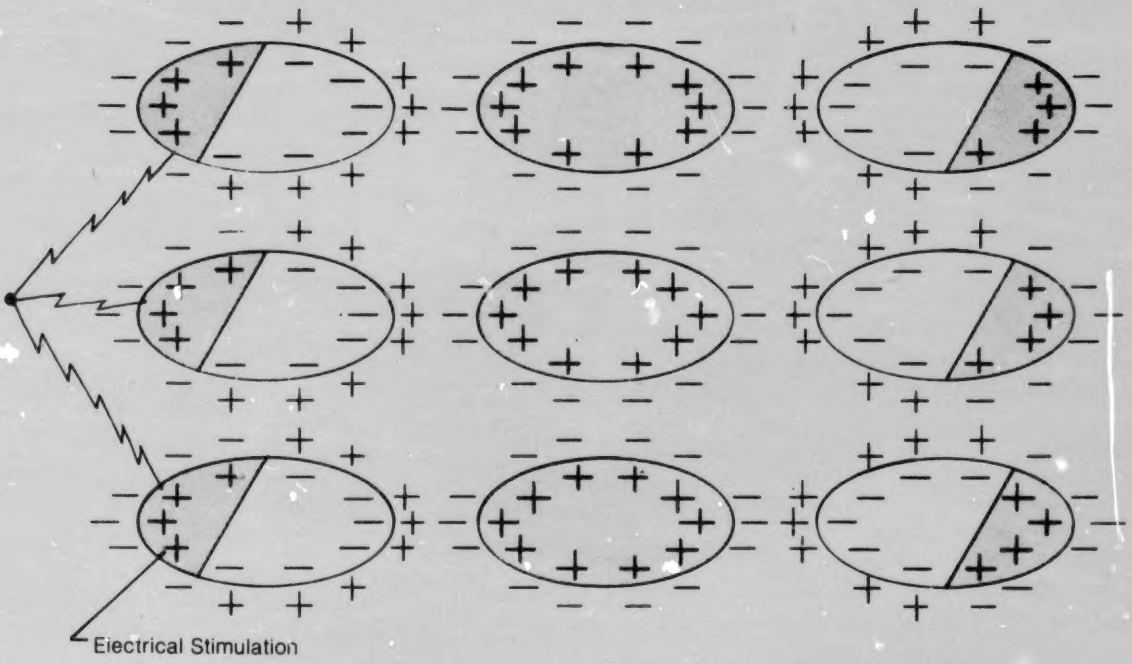


Figure 25. How Heart Cells Depolarize in Unison

From the SA node, the depolarization wave spreads through the atria and causes them to contract. The atrial muscles are not connected to the ventricular muscles, therefore, the contraction of the atrial muscles will not stimulate the ventricular muscles to contract. There are three atrial internodal pathways leading from the SA node that carry the electrical impulse to the AV node.

From the AV node, the impulse travels to the bundle of His. From the bundle of His, the impulse is conducted to the right and left bundle branches, which in turn, conduct the impulse to the Purkinje fibers. Stimulation of the Purkinje fibers results in ventricular contraction.

If the SA node starts to depolarize more slowly than any of the other cells, it will no longer be the pacemaker. At that time secondary pacemakers take over—such as the AV node or the bundle branches. The AV node depolarizes 40 to 60 times per minute, and the bundle branches depolarize at a rate of 20 to 40 times per minute. Ischemia, hypoxia, acidosis, or electrolyte imbalances can stimulate the ventricular and atrial cells to act as pacemakers and depolarize spontaneously. A pacemaker that occurs outside the normal conduction pathway is identified as an ectopic focus.

Atrial and ventricular depolarization are electrical events that can be sensed by electrodes on the skin surface. If the electrical impulses are amplified, they can be recorded on the EKG. Therefore, the EKG represents the sum of the electrical activity of the heart but not of the mechanical activity. The EKG does not reveal how well the heart is contracting.

## Components of the EKG Record

During a normal cardiac cycle, the SA node depolarizes first and transmits an electrical impulse to stimulate both atria. This produces a deflection called a P wave. The P wave represents atrial depolarization.

The electrical impulse then reaches the AV node where there is a delay that allows the ventricles to fill with blood. After the pause, the electrical impulse is then conducted to the bundle of His. From the bundle of His, the impulse travels through the right and left bundle branches to the Purkinje fibers and ultimately to the ventricular muscle cells. This process produces the QRS complex that represents ventricular depolarization. It takes approximately 0.10 second for the electrical impulse to depolarize the ventricles. Therefore, the normal time duration for a QRS complex is 0.10 second or less.

After the QRS complex, there is a pause called the S-T segment, which is followed by a T wave. The T wave represents ventricular repolarization. Ventricular repolarization is strictly an electrical event; there is no associated mechanical activity.

Segments and intervals are also identified on the EKG. A segment represents a section of the EKG between waves. The S-T segment represents the time between ventricular depolarization (end of S wave) and ventricular repolarization (beginning of the T wave). An interval is a section of the EKG that includes waves. The P-R interval represents the time duration from atrial depolarization (beginning of the P wave) to the beginning of ventricular depolarization (beginning of the QRS complex). The normal P-R interval duration is 0.12 to 0.20 second. The R-R

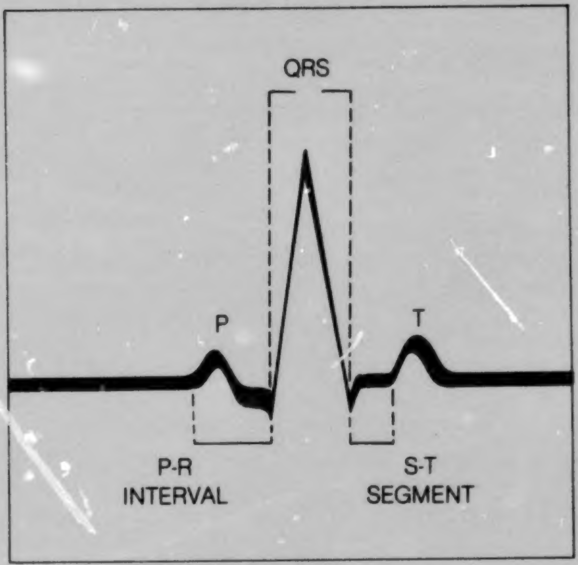


**Figure 26. EKG Strip Showing Normal Segment**

interval represents the time period between two cardiac cycles (beginning of one QRS complex to the beginning of the subsequent QRS complex) (see Fig. 6.26).

## Reading an EKG Rhythm Strip

An EKG is recorded on graph paper composed of fine vertical and horizontal lines spaced 1 mm apart forming 1 mm squares. At every 5-mm interval, there is a heavy black line. The height or depth of EKG waves may be measured vertically in millimeters and represents a measure of voltage.

The time duration of any wave is measured horizontally. At a normal recording speed of 25 mm/second, each small millimeter square equals 0.04 second. Each large 5-mm square between the heavy black lines equals 0.2 second (see Fig. 6.27).

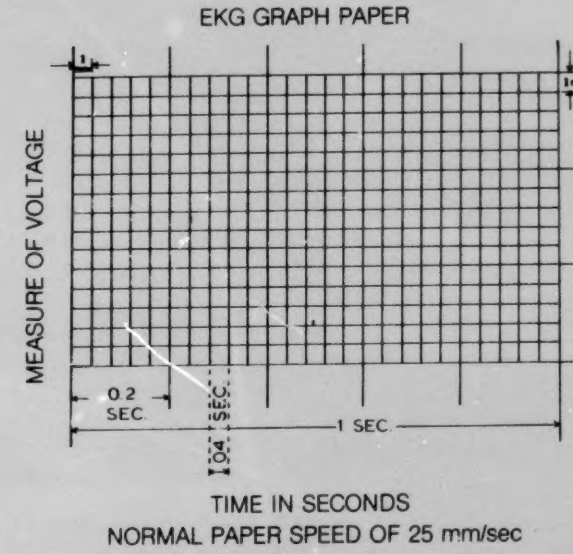


**Figure 27. EKG Strip Showing How It is Divided into time Segments**

Five basic questions should be answered when an EKG rhythm strip is analyzed systematically:

- What is the rate?
- Is the rhythm regular or irregular?
- Are there P waves and do they have any relationship to the QRS complex?
- What is the P–R interval and is it consistent?
- What is the QRS duration?

What is the rate? The heart rate is the number of cardiac cycles that occur per minute. Both the number of ventricular complexes and the number of P waves that occur per minute should be calculated. Normally, the atrial rate is the same as the ventricular rate.

A normal heart rate is between 60 and 100 beats per minute. A heart rate above 100 beats per minute is identified as a tachycardia. A heart rate below 60 beats per minute is called a bradycardia.

There are several methods that can be used to determine heart rate. Calculator rulers are special devices that can be used to determine rate. However, if a calculator is unavailable during an emergency situation, other methods of calculating heart rates must be used.

At the top of the EKG paper, there are small vertical marks that occur at 3-second intervals. Two of these intervals represent 6 seconds. Ten of the 6-second strips equal 1 minute. To calculate the heart rate, the paramedic should count the number of QRS complexes in the 6-second strip and multiply by 10. This is an "approximate" heart rate and is slower than the actual heart rate. The 6-second count can be used for regular and irregular rhythms.

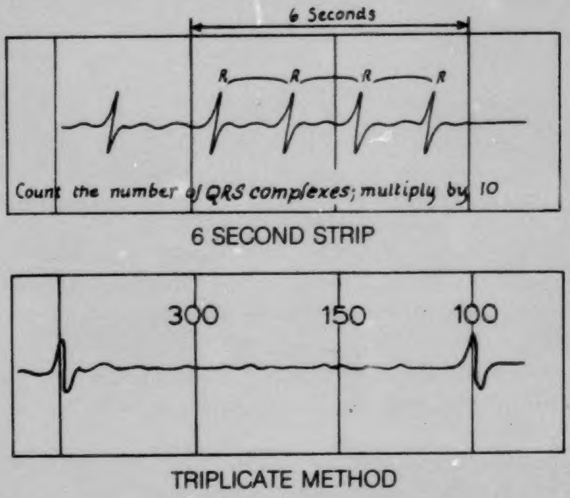


**Figure 28. How to Use the Triplicate Method of Determining the Rate from an EKG Strip**

A third method to calculate heart rate is the triplicate method. The paramedic can find an R wave that falls on a heavy black line. The next heavy black line is designated as 300 followed by lines designated as 150 and 100. The next three lines after 300, 150, and 100 are designated 75, 60, and 50. Wherever the second R wave falls is the heart rate.

The triplicate method can be used only if the rhythm is regular. If the rhythm is irregular or the heart rate is below 50, the 6-second count must be used (see Fig. 6.28).

Is the rhythm regular or irregular? Are the distances between successive R–R intervals equal or unequal? If the R–R intervals are equal, the rhythm is said to be regular. If the duration of the R–R intervals constantly varies, the rhythm is termed irregular.

Are there P waves? The P wave represents atrial depolarization. Therefore, P waves are present on the normal EKG. If P waves are present, are the P–P intervals regular or irregular? Are the P waves consistent in configuration? What is the P:QRS ratio? Is there one P wave for each QRS and does the QRS follow the P wave?

What is the duration of the P–R interval? The P–R interval represents the time from the beginning of atrial depolarization to the beginning of ventricular activation. The normal P–R interval is 0.12 to 0.20 second (3 to 5 little boxes). The P–R interval must be measured to determine if it is prolonged or greater than 0.20 second or if it is shorter than 0.12 second. Two or three successive P–R intervals should be measured to determine if the P–R interval remains constant.

What is the QRS duration? The QRS complex represents ventricular depolarization. The duration of a normal QRS complex is 0.10 second or less (2½ little boxes) and indicates that the impulse has been conducted normally from the AV junction, through the bundle of His, the left and right bundles, and the Purkinje system. A QRS duration of greater than 0.10 second signifies an abnormality in ventricular conduction.

## Unit 5. Arrhythmia Recognition

Ninety percent of patients with AMI will experience a cardiac arrhythmia sometime during the course of their illness. Fifty percent of the arrhythmias during AMI are life threatening and most frequently occur within the 1st hours after the infarction. Left untreated, these arrhythmias will lead to cardiac arrest. The cause of death in most AMI patients who die before reaching a hospital is a potentially treatable cardiac arrhythmia.

### General Concepts

Arrhythmias are disturbances in rate, rhythm, or conduction; they have many causes. Arrhythmias that occur during AMI are caused usually by either hypoxia in the infarcted muscle or by ischemia in the conducting system.

In addition to necrosis of the heart muscle or ischemia in the conduction system, many other disorders can cause arrhythmias. Imbalances in the autonomic nervous system may result in arrhythmias. Increased sympathetic tone increases the firing rates of both the SA node and secondary pacemakers. In contrast, increased parasympathetic tone decreases the SA node firing rate. However, secondary pacemakers are less sensitive to parasympathetic stimulation. Therefore, when the SA node is excessively slowed by parasympathetic activity, a secondary pacemaker may actually have a faster firing rate and may take over as the pacemaker.

Myocardial stretch may also cause arrhythmias. This most often occurs in the atria as a result of congestive heart failure. In congestive heart failure, the atria distend to accommodate ineffective ventricular pumping.

Hypoxemia (low blood oxygen) and hypercarbia (elevated blood carbon dioxide) can cause arrhythmias as a result of pulmonary edema because of left heart failure and primary lung diseases (see Module V). Changes in blood pH such as metabolic acidosis and alkalosis may also produce cardiac arrhythmias. When lactic acid accumulates because tissues are poorly oxygenated, metabolic acidosis occurs. Metabolic alkalosis results from excessive antacid ingestion, vomiting, or excessive I.V. administration of sodium bicarbonate.

Toxic substances released from damaged cells may also affect the electrical conduction system and produce arrhythmias. These products include excessive amounts of potassium, magnesium, lactic acid, adenosine (a nucleic acid component), amino acids, and enzymes. Overdoses of cardiac drugs can likewise produce arrhythmias. These drugs include digitalis, procainamide, quinidine, atropine, lidocaine, epinephrine, dopamine, and isoproterenol.

Serum potassium and calcium imbalances may also cause cardiac arrhythmias. Hyperkalemia, or increased serum potassium, decreases the rate of ventricular depolarization and increases the rate of ventricular repolarization, which widens the QRS complex and produces tall, peaked T waves on the EKG. Hyperkalemia also slows atrial conduction and may cause prolongation of the P–R interval or may cause the P wave to disappear.

Hypokalemia, or low serum potassium, impairs myocardial contractility and increases the durations for depolarization and repolarization. Hypokalemia slows conduction in ventricular muscle. This lengthens and flattens the T wave and produces a U wave, which is a small positive wave following the T wave. Hypokalemia enhances automaticity and leads to increased activity in ectopic pacemakers and produces supraventricular or ventricular arrhythmias.

Serum calcium is important for cardiac excitability and contractility. Hypercalcemia decreases conduction velocity, that is, the QRS duration may be prolonged. AV block may also develop. Hypocalcemia does not usually cause arrhythmias, but it does decrease cardiac contractility.

Arrhythmias are clinically significant. Very slow heart rates or bradycardias (below 40 to 50 beats per minute) reduce cardiac output and frequently precede electrical instability of the heart. With slowing of the sinus rate, ectopic ventricular pacemakers may fire, producing premature ventricular contractions (PVC's) and ventricular arrhythmias.

Very rapid heart rates or tachycardias (over 120 to 140 per minute) increase the workload of the heart, resulting in myocardial ischemia and damage. Tachycardias are also associated with decreased cardiac output. Ventricular electrical instability, manifested by the presence of ectopic beats, is a serious warning that graver prelethal or lethal arrhythmias may follow.

## Introduction to Reading Arrhythmias

To recognize abnormal rhythm patterns, a working knowledge of the characteristics of a normal rhythm pattern is essential. A normal heart rate is one between 60 and 100 beats per minute. In a normal rhythm, the R–R intervals are equal; that is, the rhythm is regular. Occasionally, the R–R intervals may vary in regularity up to 0.04 second; however, this is normal and the rhythm is still considered essentially regular. The normal rhythm has P waves that are smoothly rounded and are positive in a lead II. The P waves are consistent in configuration and each precedes a QRS complex. The P–R interval is between 0.12 and 0.20 second and is constant. The QRS duration is 0.10 second or less. The QRS complexes are consistent in configuration. A rhythm strip that meets the above criteria is identified as a normal sinus rhythm.

Abnormalities may be found in any of the above criteria for analyzing a rhythm strip. The heart rate may be below 60 (bradycardia) or above 100 (tachycardia).

An abnormal rhythm is present when the R–R intervals vary by more than 0.04 second. There are regularly irregular rhythms and irregularly irregular rhythms. In a rhythm that is regularly irregular, there is a consistent repetition of R–R interval lengths. This type of rhythm suggests an ectopic focus is firing. In irregularly irregular rhythms, there is no pattern to the R–R interval lengths. An irregularly irregular rhythm suggests atrial fibrillation.

The P wave represents atrial depolarization. When analyzing a rhythm strip, the paramedic must determine if (1) P waves are present, (2) the P waves are similar in size and shape, and (3) there is any relationship between the P waves and the QRS complexes. These determinations will provide information about the pacemaker site and the conduction system. If there are no P waves in the rhythm strip, atrial fibrillation or junctional rhythm may be present. If P waves are negative in lead II, this suggests an ectopic pacemaker in the AV junction. A P wave is abnormal if it is flat or peaked, rather than smoothly rounded, and if it varies in shape and size from cycle to cycle. Distorted, varying P waves indicate several pacemaker sites at different locations throughout the atria (wandering atrial pacemaker). The relationship between the P wave and QRS complex may be altered. If the QRS complex is not preceded by a P wave, the pacemaker site is an ectopic one and not in the SA node. If a P wave is present but not followed by a QRS complex, a block is present somewhere in the AV junction, or below, preventing atrial conduction to the ventricles.

The P–R interval represents the time required for atrial depolarization and conduction of the impulse through the AV junction. The P–R interval is abnormal if it is greater than 0.20 second or less than 0.12 second. When there is disease or damage to the AV node, as sometimes occurs in myocardial infarction, conduction through the junction is slowed even more, and the P–R interval lengthens. A P–R interval greater than 0.20 second is called first-degree AV block and indicates injury to the AV junction. If the P–R interval is less than 0.12 second, this suggests an ectopic pacemaker in the AV junction. If the P–R interval varies from cycle to cycle, this is also abnormal.

The QRS complex represents ventricular depolarization. A normal QRS complex is narrow, has sharply pointed waves, and has a duration of 0.10 second or less. A normal QRS indicates that conduction of the electrical impulse has proceeded normally from the AV junction through the bundle of His, the left and right bundle branches, and the Purkinje system. An abnormal QRS complex is bizarre in appearance and has a duration longer than 0.10 second. An abnormal QRS complex signifies an abnormality in conduction through the ventricles.

The paramedic should note whether a P wave precedes every QRS complex and whether the P waves and the QRS complexes have a constant relationship or seem to occur independently of one another.

To reiterate, the analysis of every EKG should include the following questions:

- What is the rate?
- Is the rhythm regular or irregular?
- Are there P waves? Is there a P wave before every QRS complex and a QRS complex after every P wave? Based on this, what is the pacemaker site?
- What is the P–R interval?
- Are the QRS complexes normal or abnormal in shape and duration?

In analyzing a rhythm strip, the paramedic must beware of artifacts. A straight line EKG with an alert, communicative patient usually indicates a loose or disconnected electrode—not a systole. Likewise, a wavy baseline simulating ventricular fibrillation may be caused by patient movement or muscle tremor. The paramedic should always observe the patient. A dangerous-looking EKG in an alert patient who is in no obvious distress should indicate to the paramedic that the electrode placement should be rechecked. Electrode placement is described later in this Module.

The remainder of this unit will discuss the interpretation and treatment of specific cardiac arrhythmias.

## SYSTEM FOR IDENTIFICATION OF ARRHYTHMIAS

Rate
  Ventricular
  Atrial

Rhythm
  Ventricular (R-R interval)

Regular

Irregular
  Regular irregularity

  Irregular irregularity

  Atrial
    Regular
    Irregular

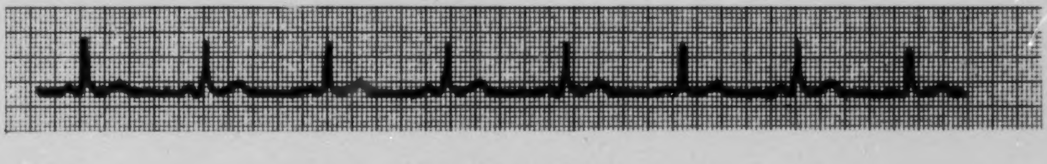
Regular irregularity

Irregular irregularity
  P Waves
    Configuration
    Relationship to QRS

  P-R Interval
    Duration
    Consistency

  QRS Complex
    Duration
    Relationship to P wave

*Rate:* 60 to 100 per minute.



**Normal Sinus Rhythm**

*Rhythm:* Regular.

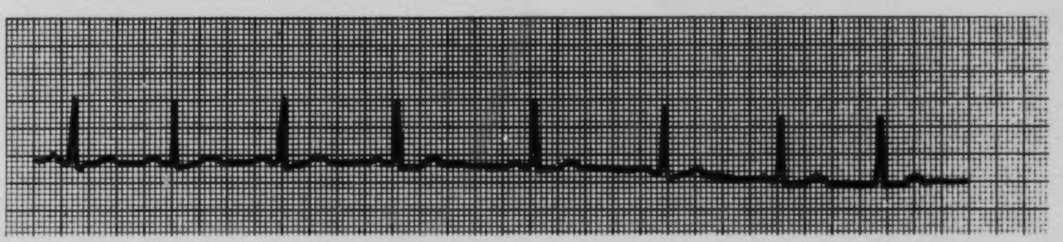
*P waves:* Precede each QRS complex with consistent configuration.

*P-R interval:* 0.12 to 0.20 second; consistent.

*QRS duration:* 0.10 second or less.

*Clinical significance:* Normal.

*Treatment:* None.



**Sinus Arrhythmia**

*Rate:* Normal but increases with inspiration and decreases with expiration.

*Rhythm:* Irregular.

*P waves:* Present, normal, preceding every QRS.

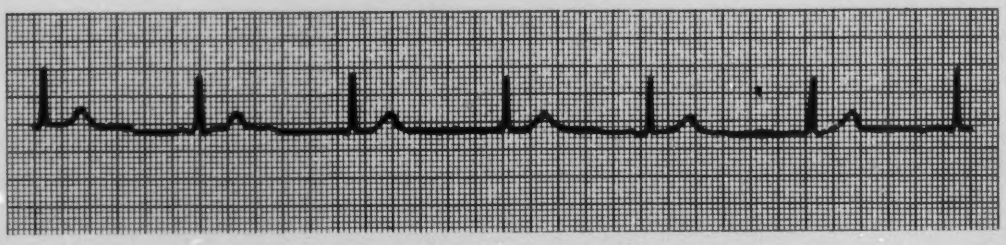
*P-R interval:* Normal and constant.

*Pacemaker site:* SA node.

*QRS complex:* Normal.

*Clinical significance:* Sinus arrhythmia is a normal phenomenon caused by the effects of respiration on the parasympathetic nervous system.

*Treatment:* None.



**Sinus Bradycardia**

*Rate:* 40 to 60 per minute.

*Rhythm:* Regular, less than 60, usually 40 to 60.

*P waves:* Present, normal, each preceding QRS.

*P–R interval:* Normal.

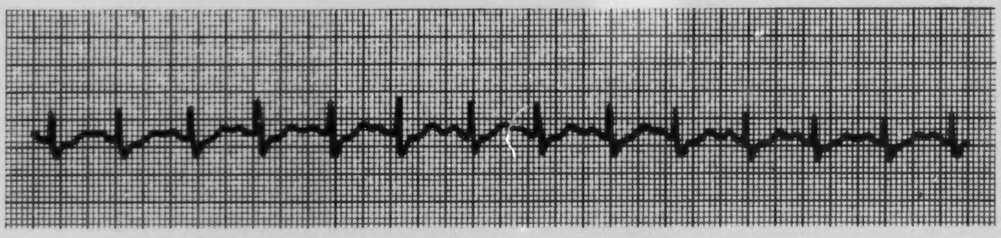
*Pacemaker site:* SA node.

*QRS complexes:* Normal.

*Clinical significance:* In young, healthy individuals, heart rates below 60 per minute may reflect good physical conditioning. However, in the presence of AMI, sinus bradycardia implies an increase in vagal (parasympathetic) tone. Sinus bradycardia may also be caused by toxic levels of certain cardiac drugs (digitalis, quinidine). A heart rate below 50 per minute may significantly reduce cardiac output and reduce perfusion of vital organs. Bradycardia promotes ventricular electrical instability and may lead to serious ventricular arrhythmias.

*Treatment:* If the blood pressure is normal, the patient is alert, and there are no ventricular ectopic arrhythmias, no treatment is necessary. If any of the following circumstances are present, administer atropine 0.5 mg I.V. push and repeat every 5 minutes until the heart rate is between 60 and 100 or until a total of 2 mg have been administered:

- Hypotension (systolic pressure of 80 mm Hg or less)
- Weak or absent pulse
- Pale, cold, clammy skin
- Agitation, confusion, or unconsciousness
- Ventricular ectopic arrhythmias



**Sinus Tachycardia**

*Rate:* 100 to 150 per minute.

*Rhythm:* Regular.

*P waves:* Present, normal, preceding each QRS complex. P waves may be buried in preceding T wave if rate is very rapid.

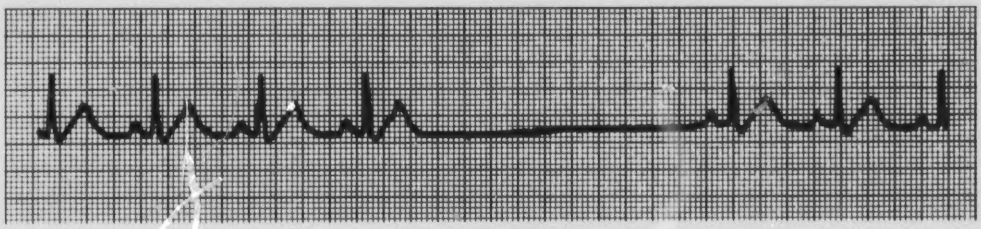
*P–R interval:* Normal.

*Pacemaker site:* SA node.

*QRS complex:* Normal.

*Clinical significance:* Sinus tachycardia may be a result of pain, fever, hypoxia, shock, congestive heart failure, or anxiety. Very rapid heart rates increase the work of the heart and may lead to further ischemia and infarction in the patient with AMI. Cardiac output may be significantly reduced when the heart rate exceeds 120 to 140 because of inadequate ventricular filling time.

*Treatment:* Treat the underlying cause—pain, hypoxia, congestive failure, shock, anxiety.



**Sinus Arrest**

*Rate:* Usually normal.

*Rhythm:* Irregular.

*P waves:* Present, normal, preceding each QRS. However, when the SA nodes does not discharge or is blocked, one or more entire P-QRS-T complexes will be absent.

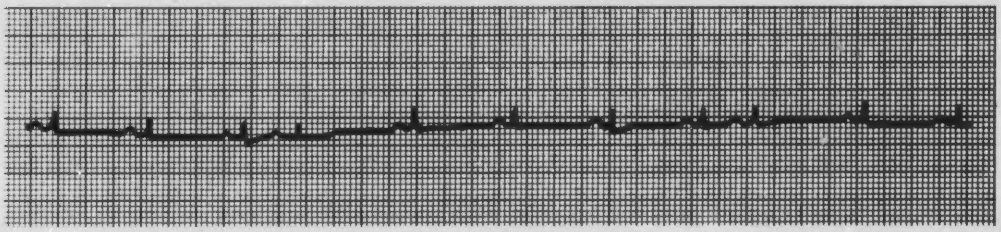
*P–R interval:* Normal and constant.

*Pacemaker site:* SA node.

*QRS complex:* Normal.

*Clinical significance:* Occasional episodes are not significant; however, if the heart rate is reduced below 30 to 50 beats per minute, cardiac output may fall and enhance the development of a ventricular ectopic focus.

*Treatment:* If the patient is asymptomatic, blood pressure is well maintained, and there is no evidence of ventricular irritability, no treatment is necessary. If there are signs of hypoperfusion or the presence of atrial or ventricular ectopic arrhythmias, treatment must be initiated to increase the heart rate. Atropine sulfate 0.5 mg is given I.V. push and repeated at 5- to 10-minute intervals until the heart rate is between 60 and 100 beats per minute or until a maximum of 2 mg has been given.



**Premature Atrial Contractions (PAC's)**

*Rate:* Determined by the number of premature supraventricular beats.

*Rhythm:* Irregular.

*P waves:* The P waves of the premature atrial contraction are often different from normal P waves in shape, size, or configuration.

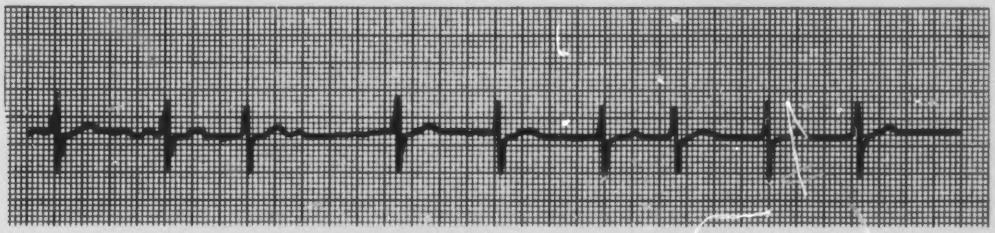
*P-R interval:* Variable, depending on the distance between the ectopic pacemaker and the AV junction.

*Pacemaker site:* The pacemaker site of the premature supraventricular beat is an ectopic focus in the atria.

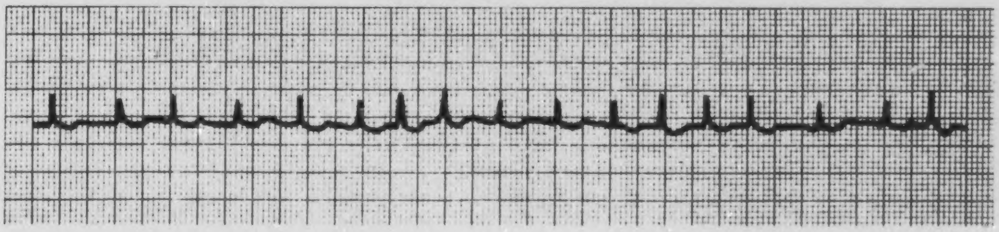
*QRS complexes:* Usually normal, but may be aberrantly conducted.

*Clinical significance:* Occasional PAC's may occur in normal individuals. Frequent PAC's suggest organic heart disease and may lead to atrial tachycardias. It is important that PAC's are distinguished from PVC's.

*Treatment:* None.



**Controlled Ventricular Response**



**Rapid Ventricular Response**

## Atrial Fibrillation

*Rate:* Atrial rate is over 350, not measurable on the rhythm strip; ventricular rate is 100 to 160 if untreated; may be slower if the patient is taking digitals.

*Rhythm:* Irregularly irregular.

*P waves:* Absent; instead there are fibrillatory waves (f waves), which may be coarse or so fine that they resemble a straight line.

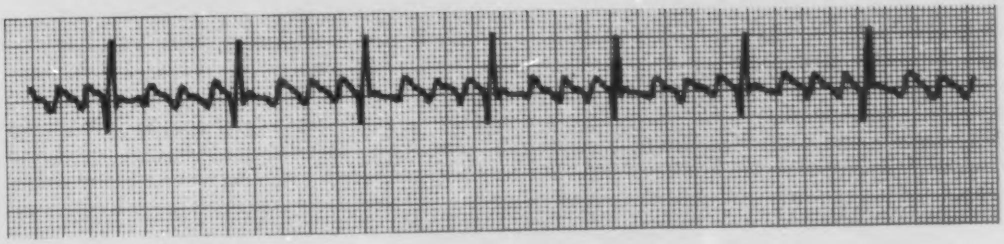
*P–R interval:* Not measurable.

*Pacemaker site:* Multiple, ectopic atrial pacemaker sites.

*QRS complexes:* Usually normal.

*Clinical significance:* Atrial fibrillation is usually associated with underlying heart disease. When it occurs in the presence of AMI, it may indicate damage to the SA node or atria. In atrial fibrillation, the atria and ventricles do not contract in sequence, the cardiac output falls by as much as 25 percent. In addition, if the ventricular response exceeds 120 to 140 beats per minute, cardiac output is further compromised and the work of the heart is increased.

*Treatment:* Usually none in the field. If the patient evidences signs of inadequate cardiac output (hypotension; confusion; coma; or cold, clammy skin) cardioversion may be required.



Atrial Flutter

*Rate:* Atrial rate is 240 to 350 per minute; ventricular rate is affected by AV conduction and digitalis.

*Rhythm:* Atrial rhythm is regular; ventricular response regular with 2:1 AV conduction when untreated, but may be irregular if patient is on digitalis.

*P waves:* No true P waves present. Instead there are flutter waves (F waves), which occur in a jagged, "sawtooth" pattern.

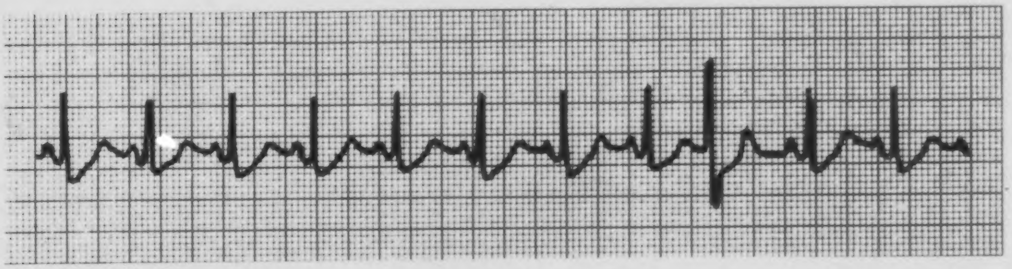
*P–R interval:* None measurable.

*Pacemaker site:* An ectopic focus in the atrium.

*QRS complexes:* Usually normal in configuration; a QRS may follow every second, third, or fourth flutter wave.

*Clinical significance:* Atrial flutter is usually caused by some underlying cardiac disease or damage. If there is a rapid ventricular response, the workload of the heart is increased and cardiac output may be compromised.

*Treatment:* If the patient is clinically stable, no treatment is indicated in the field. If the patient evidences inadequate cardiac output (hypotension; cold, clammy skin; confusion; or coma), cardioversion may be required.



Premature Nodal (Junctional) Contractions (PMS's)

*Rate:* Will be determined by the number of PNC's.

*Rhythm:* Irregular; the premature junctional beat is preceded by a shorter than normal R–R interval.

*P waves:* May be present or absent; when present, they differ in shape from normal P waves and may occur before, during, or after the QRS.

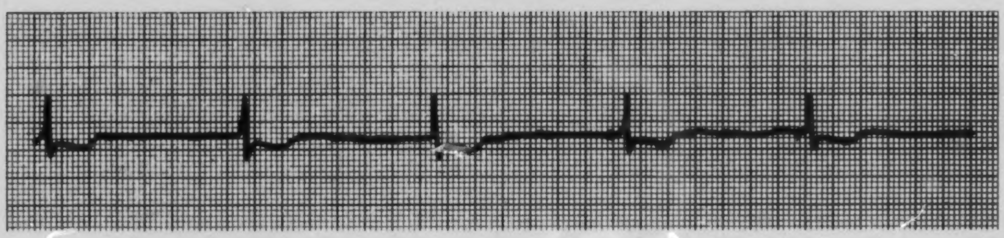
*P–R interval:* Less than 0.12 second.

*Pacemaker site:* An ectopic focus in the AV junction.

*QRS complexes:* Normal.

*Clinical significance:* Occasional PNC's are not significant. Frequent PNC's indicate irritability of the AV junction and may be a forewarning of serious arrhythmias.

*Treatment:* None.



Junctional Rhythm

*Rate:* Atrial—dependent upon mechanism for arrhythmia; ventricular—40 to 60 per minute.

*Rhythm:* Regular.

*P waves:* If present, usually regular; one P wave for every QRS complex. Because of the origin of the impulse in the AV junction, configuration of P waves may be different and may occur before, during, or after the QRS.

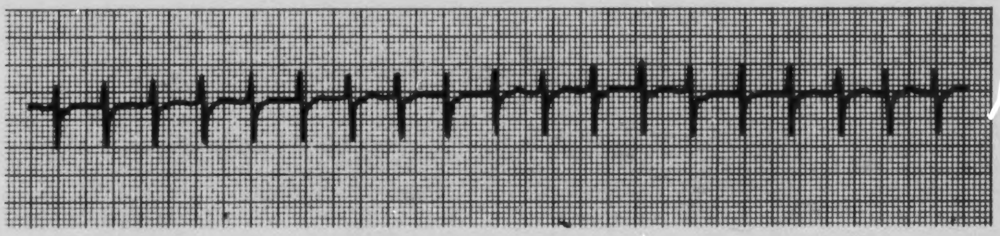
*P–R interval:* If P wave precedes QRS, less than 0.12 second.

*Pacemaker site:* AV junction.

*QRS duration:* Normal.

*Clinical significance:* Slowing of atrial pacemaker allows AV junction to assume control. May give rise to potential lethal arrhythmias. May be due to digitalis intoxication.

*Treatment:* Depends on clinical situation. If rate is slow and patient is symptomatic due to lowered carbon monoxide, treatment is same as for sinus bradycardia. If rate is too fast and patient is symptomatic due to increased carbon monoxide, treatment is to depress automaticity (Pronestyl).



Supraventricular Tachycardia

*Rate:* About 150 to 240 per minute.

*Rhythm:* Regular.

*P waves:* May be absent or abnormal.

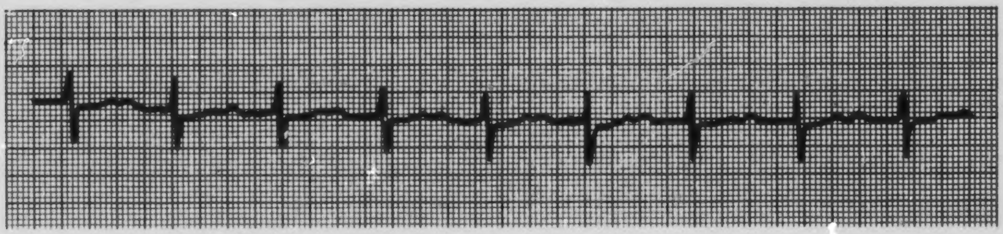
*P–R interval:* May be none; if P wave precedes the QRS, duration depends on the distance of the pacemaker site from the AV junction.

*Pacemaker site:* A part of the atria or AV junction other than the SA node.

*QRS complexes:* Normal.

*Clinical significance:* May indicate structural damage to SA or AV node. May be benign in healthy hearts. Cardiac output may be reduced.

*Treatment:* Carotid sinus massage (see Unit 6).



**First-Degree AV Block**

*Rate:* Normal.

*Rhythm:* Regular.

*P waves:* Present, normal, preceding each QRS complex.

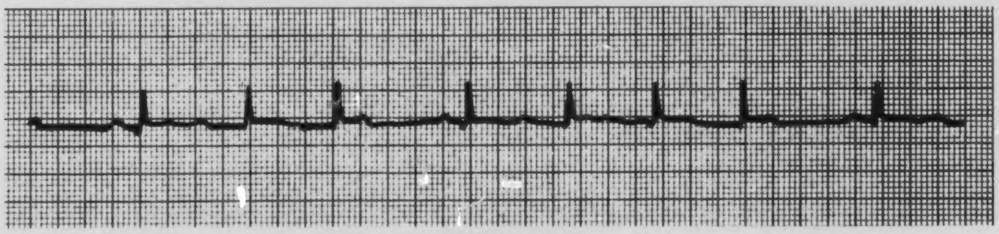
*P–R interval:* Prolonged beyond 0.20 second.

*Pacemaker site:* SA node.

*QRS complexes:* Normal.

*Clinical significance:* First-degree AV block may be caused by damage to the AV junction, increased vagal (parasympathetic) tone, or toxicity from certain cardiac drugs such as digitalis. In the context of AMI, first-degree AV block may warn of advanced degrees of block.

*Treatment:* No treatment is indicated.



**Second-Degree AV Block: Mobitz Type I (Wenckebach's Disease)**

*Rate:* Atrial rate is normal; ventricular rate may be normal or slow depending on the degree of block.

*Rhythm:* P–P intervals regular; R–R intervals irregular.

*P waves:* Present and normal; a QRS complex is absent after every third, fourth, or fifth P wave. Hence P waves are more numerous than QRS complexes.

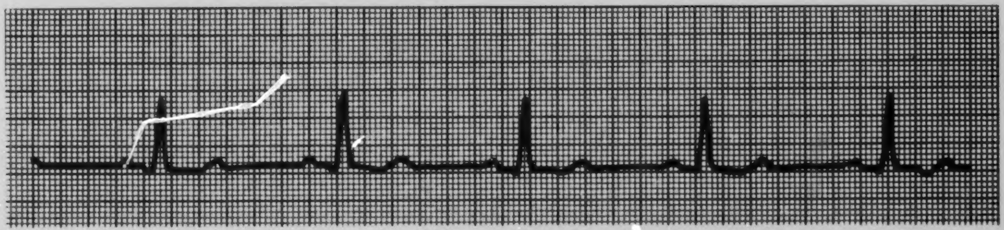
*P–R interval:* Progressively lengthens until a QRS complex is dropped.

*Pacemaker site:* SA node.

*QRS complexes:* Normal.

*Clinical significance:* Mobitz Type I block is a less serious type of second-degree AV block and is usually transient. Mobitz I may be caused by digitalis intoxication. Occasionally Mobitz I block can progress to complete heart block. Careful monitoring is indicated.

*Treatment:* None if cardiac output is maintained. If there are signs of inadequate cardiac output (hypotension; cold, clammy skin; confusion; or coma), administer atropine sulfate 0.5 mg by I.V. bolus and repeat every 5 minutes until the pulse is between 60 and 100 or a total dose of 2 mg has been given. If ineffective, isoproterenol 2 mg in 500 cc D5W may be started I.V. piggyback and run at a flow rate that is titrated to patient response—that is, until a blood pressure over 80 mm Hg or a heart rate above 60 per minute is reached.



**Second-Degree AV Block: Mobitz Type II**

*Rate:* Atrial rate is normal; ventricular rate may be normal or slow depending on the degree of block.

*Rhythm:* P–P interval regular; R–R interval regular.

*P waves:* Present, normal; QRS complex is absent after every second, third, or fourth P wave. Hence P waves are more numerous than QRS complexes.

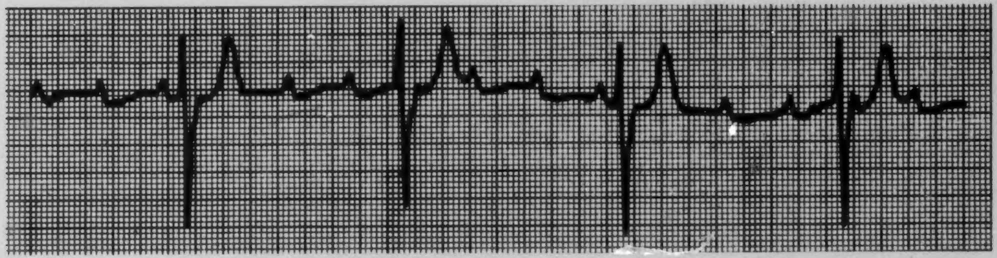
*P–R interval:* P–R for conducted beats will be consistent.

*Pacemaker site:* SA node.

*QRS complexes:* May be normal.

*Clinical significance:* Decreased cardiac output due to slow ventricular rates. Often a precursor to complete heart block.

*Treatment:* If signs of inadequate output are present, administer atropine 0.5 mg I.V. push. If this is drug ineffective, initiate isoproterenol 2 mg in 500 cc D5W push and titrate to patient response, until a heart rate of 60 or a blood pressure of 80 mm Hg systolic is reached.



**Third-Degree AV Block (Complete Heart Block)**

*Rate:* Atrial rate normal; ventricular rate usually 60 to 100 per minute.

*Rhythm:* Regular (P–P interval regular; R–R interval regular)

*P waves:* Present, normal; no consistent relationship to QRS complexes.

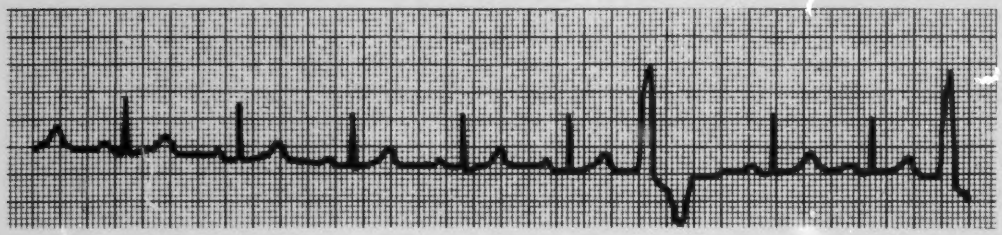
*P–R interval:* Not measurable; there is no consistent relationship between the P waves and the QRS complexes.

*Pacemaker site:* SA node is the pacemaker for the atria; however, impulses from the SA node are blocked at the AV junction. Therefore, the ventricles are driven by a pacemaker in the AV junction or in the ventricles.

*QRS complexes:* May be normal if the ventricular pacemaker is the AV junction. If the QRS complex is normal, the ventricular rate will be faster—40 to 50. If the pacemaker is in the ventricles, the rate will be slow and the QRS complexes will be wide and bizarre.

*Clinical significance:* If the heart rate is below 50 beats per minute, cardiac output may be significantly compromised. In third-degree heart block, contraction of the atria and ventricles is no longer synchronized. The ventricles do not fill completely prior to each contraction, and cardiac output is further reduced.

*Treatment:* Atropine sulfate 0.5 mg I.V. bolus. May be repeated every 5 minutes until the heart rate is above 60 or until a total dose of 2 mg has been given. If atropine is ineffective, isoproterenol drip may be initiated. Add 2 mg isoproternol to 500 cc D5W and titrate at a flow rate that maintains the heart rate at above 60 or a blood pressure above 80 mm Hg systolic. Never give lidocaine to a patient with complete heart block, no matter how bizarre the QRS complexes appear.



## Premature Ventricular Contractions (PVC's)

*Rate:* Determined by the number of PVC's.

*Rhythm:* Irregular. A shorter than normal R–R interval separates the PVC from the preceding normal beat. Most PVC's are followed by a compensatory pause. A compensatory pause occurs because the regular sinus impulse cannot activate the ventricles while they are still in the absolute refractory period following the PVC. Therefore, there is a pause until a second impulse from the SA node reaches the ventricles. As a result, the interval between beats before and after the PVC will be twice the normal R–R interval.

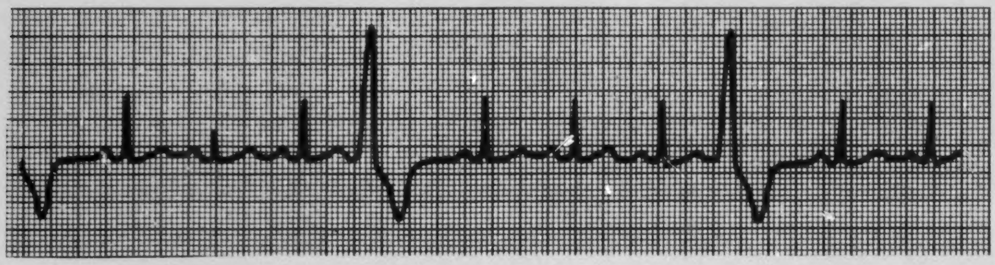
*P waves:* Absent before PVC's.

*P–R interval:* None in the PVC, because it is not preceded by a P wave.

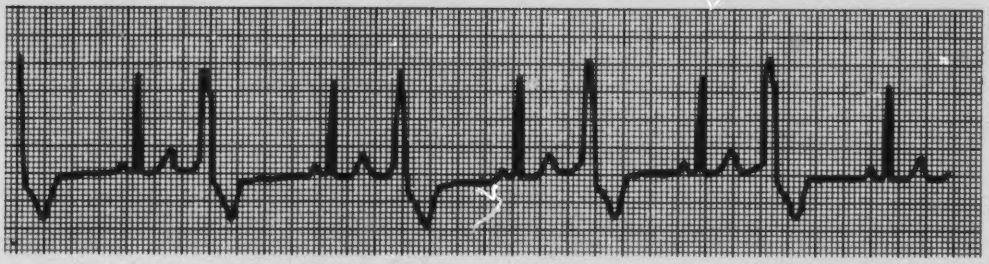
*Pacemaker site:* The pacemaker site for the PVC is an ectopic focus in one of the ventricles.

*QRS complexes:* Distorted, wide (0.12 second or greater), bizarre.

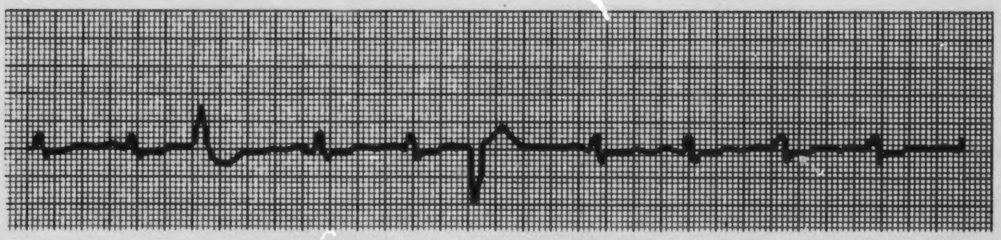
*Clinical significance:* Occasional PVC's may occur in normal persons. However, in the presence of AMI, PVC's indicate increased ventricular irritability and must be treated. Certain types of PVC's are of particular concern, because of their tendency to progress to ventricular tachycardia or fibrillation. These include:



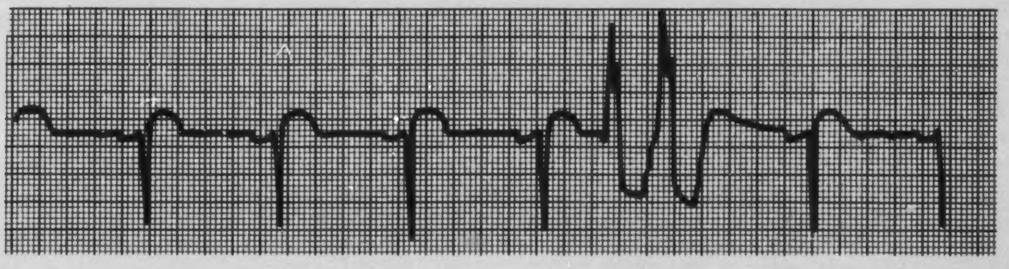
- Frequent PVC's (more than 6 per minute).



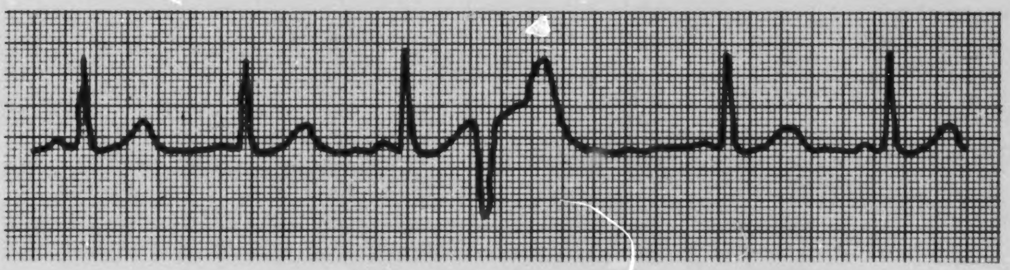
- A pattern with PVC's occurring every other beat is called ventricular bigeminy.



- Multifocal PVC's. These are of different sizes and shapes and indicate that there are multiple ectopic foci in the ventricle.

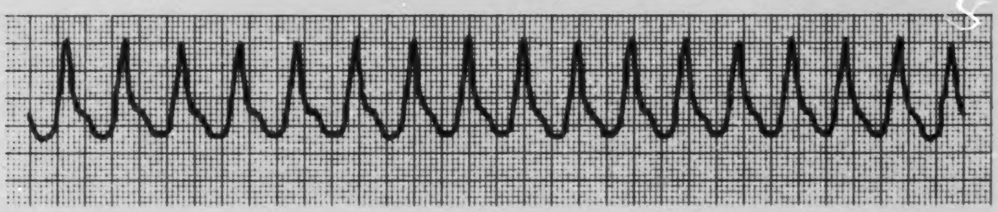


- Bursts of two or more PVC's in a row (salvos). These may progress rapidly to ventricular tachycardia.



- R–on–T phenomenon. The downslope of the T wave represents the vulnerable period in which the ventricles are extremely excitable. A PVC occurring during the vulnerable period may initiate a repetitive response or ventricular fibrillation.

*Treatment:* In the setting of AMI, all PVC's should be treated. Administer lidocaine 50 to 100 mg I.V. bolus followed by lidocaine infusion; the latter is prepared by adding 2 g of lidocaine to a 1,000 cc of D5W and infusing 1 to 4 mg per minute. If PVC's are present in sinus bradycardia, the drug of choice is atropine 0.5 mg I.V. to treat the rate not the rhythm.



Ventricular Tachycardia

*Rate:* 100 to 250 per minute.

*Rhythm:* Regular.

*P waves:* Often not seen because they are buried in the QRS complexes; when they are visible, they have no apparent relationship to the QRS complexes.

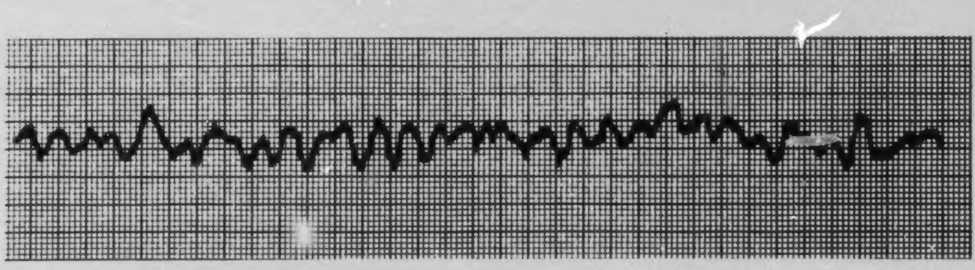
*P–R interval:* There is no P–R interval.

*Pacemaker site:* An ectopic focus in the ventricle.

*QRS complexes:* Distorted, wide (0.12 second or greater), bizarre.

*Clinical significance:* A very grave and dangerous arrhythmia, which may lead to ventricular fibrillation. Causes marked reduction in cardiac output.

*Treatment:* If the patient is conscious, administer lidocaine 50 to 100 mg I.V. bolus followed by an infusion of lidocaine. If there is evidence of inadequate cardiac output (hypotension; cold, clammy skin; confusion; or coma), synchronized cardioversion is indicated at 25 joules. If normal sinus rhythm is achieved, treat with lidocaine as described above. If the patient is still in ventricular tachycardia, the physician may order another attempt at cardioversion at higher energy levels.



Ventricular Fibrillation

*Rate:* 150 to 300 chaotic oscillations.

*Rhythm:* Totally irregular.

*P waves:* Not seen.

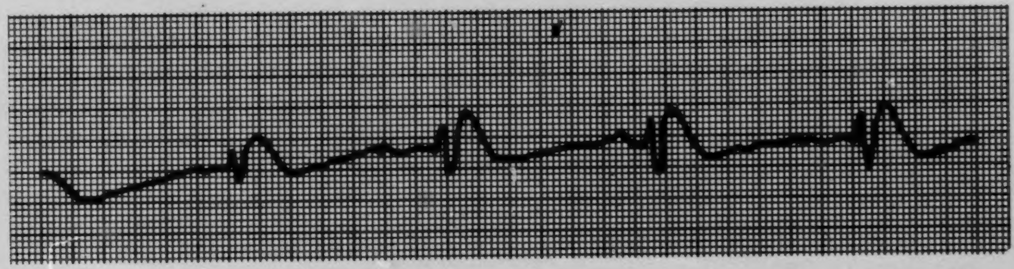
*P–R interval:* None.

*Pacemaker site:* Numerous ventricular ectopic foci.

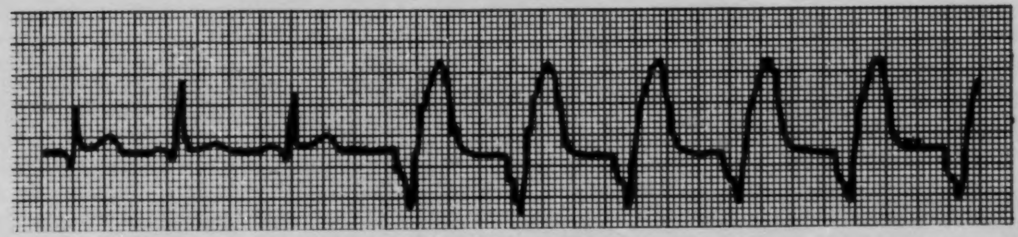
*QRS complexes:* Absent. In place of QRS complexes are fibrillatory waves of varying size, shape, and duration.

*Clinical significance:* Ventricular activity is totally disorganized; the ventricular muscle quivers rather than beats. As a result, there is no cardiac output. Biological death is inevitable unless cardiopulmonary resuscitation (CPR) is initiated within a few minutes.

*Treatment:* Immediate defibrillation at maximum energy output. If a defibrillator is unavailable or direct current shock is ineffective, CPR must be carried on until other measures are instituted (see Unit 6).



**Usual Idioventricular Rhythm**



**Accelerated Idioventricular Rhyhm**

### Idioventricular Rhythm

*Rate:* 20 to 40, accelerated idioventricular rhythm is faster (60 to 100).

*Rhythm:* May be regular or irregular.

*P waves:* Usually not seen.

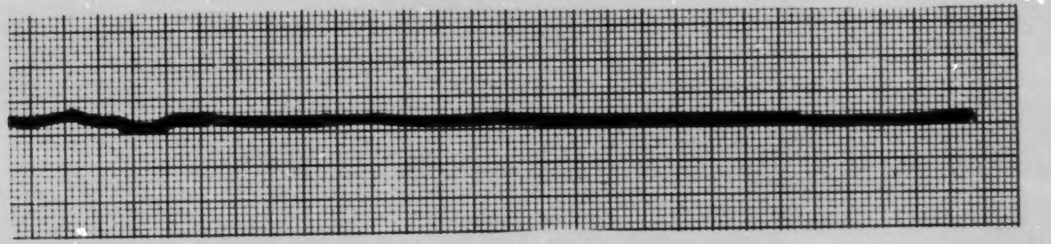
*P–R intervals:* None.

*Pacemaker site:* Ventricles.

*QRS complexes:* Distorted, wide (0.12 second), bizarre.

*Clinical significance:* Cardiac output cannot be maintained with ventricular rates of 20 to 40. This rhythm is often seen following a cardiac arrest and should be treated. Accelerated idioventricular rhythm may be considered benign.

*Treatment:* Antiarrhythmic drugs are contraindicated. Isoproterenol 2 mg to 500 ml D5W may be used to increase the cardiac rate and the contractile force of the heart.



**Cardiac Standstill (Asystole)**

*Rate:* Less than five ectopic beats per minute.

*Rhythm:* None—straight line.

*P waves:* None.

*P–R interval:* None.

*Pacemaker site:* None consistently.

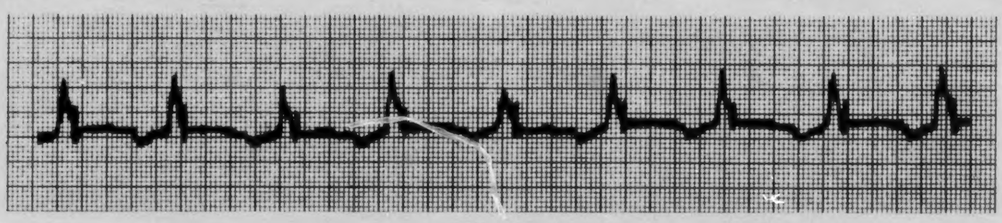
*QRS complexes:* None or rare, bizarre.

*Clinical significance:* Asystole is a total absence of electrical activity in the heart; there is no cardiac output.

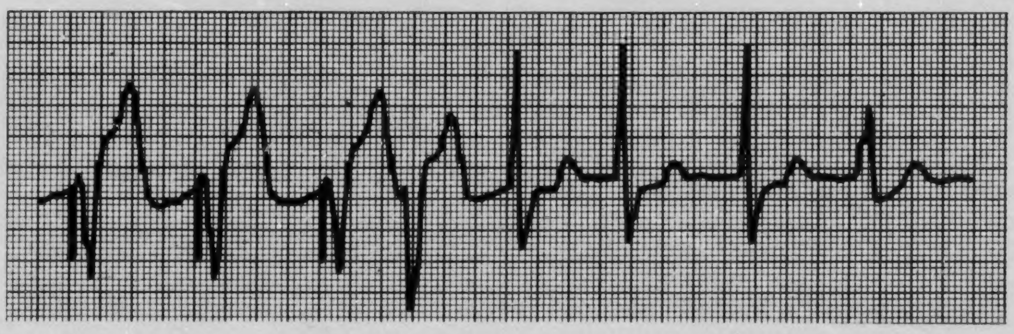
*Treatment:* CPR and drug therapy, including epinephrine, bicarbonate (see Unit 6).

## ELECTROMECHANICAL DISSOCIATION (EMD)

EMD usually demonstrates itself in profound cardiovascular collapse. There will be an orderly electrical rhythm on the EKG monitor but ineffective mechanical function of the heart. There is electrical activity but no mechanical activity. There will be no palpable pulse or blood pressure. Treatment of choice for EMD is calcium chloride 0.5 g (5 ml) I.V. and CPR.



**Fixed Rate**



**Demand Rate**

### Pacemaker Rhythms

*Rate:* Variable, depending on the pacemaker setting. The rate should be above 60 per minute if the pacemaker is functioning properly.

*Rhythm:* Regular or irregular.

*P waves:* Normal when present; may or may not be followed by QRS. Pacemaker spikes will precede some QRS complexes.

*P–R interval:* May be normal or prolonged when present.

*Pacemaker site:* Electronic pacemaker and sometimes SA node.

*QRS complexes:* QRS complexes following a pacemaker spike are wide and bizarre, resembling PVC's.

*Clinical significance:* Pacemaker rhythms indicate the patient has an electronic pacemaker in place. A pacemaker is an artificial device used to stimulate the heart when the electrical conduction system is malfunctioning. The pacemaker consists of an implanted battery-operated electrical pulse generator and a wire that delivers the impulse to the ventricle. Pacemakers may have fixed firing rates or may be demand pacemakers. Most pacemakers in current use are demand pacemakers, which fire at a preset interval from the last R wave. When the patient's heart rate is above this level, the pacemaker remains silent.

*Treatment:* None unless the pacemaker malfunctions.

# Unit 6. Techniques of Management

Management of cardiac emergencies through the use of drugs, defibrillation, cardioversion, rotating tourniquets, carotid sinus massage, intracardiac injections, and mechanical cardiopulmonary resuscitation devices is discussed in this unit.

## Drug Therapy

Drugs used to treat arrhythmias alter the heart's electrical properties of automaticity, excitability, and conductivity. Automaticity refers to the ability of certain cardiac cells to initiate impulses spontaneously—without nervous stimulation. The activity of the SA node, ectopic atrial pacemakers, the AV junction, and ectopic ventricular pacemakers are influenced by antiarrhythmic drugs.

Drugs that increase pacemaker automaticity in bradycardia are atropine and isoproterenol. Atropine increases the firing rates of the SA node and AV junction. Isoproterenol increases the firing rates of atria and ventricles as well as the SA node and AV junction.

Drugs that suppress or decrease automatic firing in tachyarrhythmias include lidocaine, procainamide and quinidine, and propranolol. Lidocaine decreases ventricular automaticity. Procainamide and quinidine decrease automaticity in the atria, AV junction, and ventricles. Propranolol decreases automaticity in the ventricles in addition to the SA node, AV junction, and atria.

Excitability refers to the ability of the conduction system to initiate an electrical stimulus, which causes the cardiac muscle fibers to depolarize and contract. Drugs that decrease excitability are useful in managing tachyarrhythmias. These drugs include lidocaine, procainamide, quinidine, propranolol, and bretyliums. Lidocaine decreases excitability in the bundle of His, Purkinje fibers, and ventricles. Procainamide, quinidine, and propranolol decrease excitability in the atria as well as in the His-Purkinje system and ventricles. Bretylium, while not a front-line antiarrhythmic agent, may be useful in treating ventricular tachyarrhythmias which are unresponsive to other agents.

Conductivity is the ability of the electrical conduction system to transmit excitation impulses. Drugs that increase electrical conductivity in bradyarrhythmias are procainamide, quinidine, atropine, and isoproterenol. These drugs increase conductivity in the AV node.

Drugs are also used to decrease conductivity in the presence of tachyarrhythmias. These include propranolol, which decreases atrial conductivity, and digoxin, which decreases conductivity in the AV node (see Table 6.5).

This unit discusses in more detail some of the significant drugs used to treat arrhythmias. These drugs include atropine, isoproterenol, lidocaine, procainamide, quinidine, propranolol, and digoxin.

1. *Atropine* reduces vagal tone by blocking parasympathetic stimulation of the SA node and the AV junction. As a result, there is an increase in automaticity of the SA node and AV junction and in conductivity through the AV node. These effects increase heart rate, cardiac output, and blood pressure. Therefore, the primary use for atropine is to increase the heart rate in bradyarrhythmias. Atropine is indicated when the heart rate is below 50 beats per minute and is accompanied by one of the following signs:

- Systolic blood pressure of 80 mm Hg or less.
- Weak or absent pulse.
- Pale, cold, clammy skin.
- Agitation, confusion, or unconsciousness.
- Atrial or ventricular ectopic arrhythmias.

The above signs may occur in the following types of bradyarrhythmias: sinus bradycardia, second-degree heart block (Mobitz Types I and II), or third-degree heart block. Slow ventricular rates accompanying atrial flutter or atrial fibrillation may also be increased with atropine; however, this may be dangerous in the field.

If the physician orders this treatment for a patient with bradycardia, the usual dose of atropine is 0.5 mg I.V. push injected within 1 minute following recognition of the disorder. This dose may be repeated every 5 minutes until the heart rate is between 60 and 100 beats per minute or until a total dose of 2 mg has been given. This dose appears to produce full cardiac vagal blockage in man.

Side effects of atropine include dryness of the mouth, blurred vision, urinary retention, constipation, worsening of preexisting glaucoma, decreased sweating, pupil dilation, and headache. Atropine may also cause a tachycardia and precipitate psychotic reactions.

If too small a dose of atropine (0.2 to 0.3 mg) is administered, or if the atropine is injected too slowly, the heart rate may actually decrease. This effect is dangerous because cardiac output will be decreased even further, which will predispose the heart to premature ventricular contractions, ventricular tachycardia, or ventricular fibrillation.

2. *Isoproterenol* is also used to increase the heart rate in bradyarrhythmias. Isoproterenol is a beta-receptor stimulator and causes an increase in automaticity, conductivity, force of ventricular contraction, and cardiac work. The automaticity of the SA node, AV junction, atria, and ventricles is increased as is the conductivity of impulses from the atria through the AV node. Because isoproterenol is a beta stimulator, it causes the peripheral arterioles to dilate reflexively, which lowers peripheral vascular resistance. The net effects of isoproterenol administration are increases in heart rate, stroke volume, and cardiac output at the

expense of an increase in myocardial oxygen requirement.

Isoproterenol is indicated in the treatment of bradyarrhythmias. It may also be used to treat AV heart block before and after the insertion of an artificial pacemaker. Isoproterenol may be administered by sublingual, intravenous, or intracardiac routes. The drug can also be given sublingually (10 mg) when atropine does not reverse a bradyarrhythmia; its effects begin within 15 to 30 minutes and last up to 2 hours.

Isoproterenol may also be administered via continuous I.V. drip. One ampule (5 ml) containing 1 mg of isoproterenol can be added to 500 cc D5W and infused at a rate sufficient to maintain the heart rate above 60 beats per minute.

Because isoproterenol increases cardiac work and, thus, increases the heart's need for oxygen, it may actually be dangerous to administer it in the presence of an AMI. Isoproterenol's beta-stimulating properties may precipitate ventricular arrhythmias. Thus, the drug should be used only in the presence of life-threatening bradycardias or in cardiac standstill until an artificial pacemaker can be inserted.

3. *Lidocaine* is used to suppress ventricular ectopic activity. It exerts its antiarrhythmic effect by decreasing automaticity in the His-Purkinje system in the ventricles. Lidocaine also decreases the excitability of the His-Purkinje system by decreasing the response to electrical stimuli. Lidocaine is the primary agent for suppression of ventricular ectopic activity. It has very little effect on cardiac output or blood pressure when used in therapeutic doses.

Lidocaine is indicated in the treatment of premature ventricular contractions, ventricular tachycardia, ventricular fibrillation that recurs following defibrillation, and ventricular arrhythmias associated with digitalis toxicity. Lidocaine may be contraindicated in patients with a history of allergy to anesthetics such as Novocain used by dentists. Lidocaine should not be administered in second- or third-degree heart block, in the presence of sinus bradycardia, or in patients with a history of fainting.

Lidocaine is administered rapidly as an I.V. bolus in a dose of approximately 1 mg/kg. The drug can be given I.V. as a bolus of 75 mg over 60 seconds followed by a 50 mg bolus every 5 minutes until the arrhythmia is suppressed or until 225 mg have been given. To maintain serum blood levels initiated by the I.V. bolus, a continuous lidocaine infusion must be started after the first bolus administration. To accomplish this, 2 g of lidocaine are added to 500 cc D5W to yield a concentration of 4 mg/cc. The I.V. is then infused at a rate of 1 to 4 mg/minute.

Most side effects of lidocaine are dose related. At the dose levels mentioned in this section, automaticity of the SA node may be depressed resulting in sinus bradycardia, SA block, or cardiac arrest. Conductivity through the AV junction may also be depressed, causing AV block, and will depress conductivity in the His-Purkinje system, producing a widening of the QRS complexes.

Minor side effects of lidocaine include lightheadedness, muscle twitches, and numbness. Adverse effects medicated through the C.N.S. include drowsiness, restlessness, euphoria, hallucinations, hypotension, and convulsions.

Lidocaine is primarily metabolized in the liver. To prevent the above side effects, lidocaine must be administered cautiously to patients with a history of liver disease or to patients who have inadequate portal circulation. Such patients include those with hepatic insufficiency, such as cirrhosis of the liver and congestive heart failure, and those who are in shock or elderly.

4. *Procainamide* and *quinidine* are used to suppress rapid supraventricular tachycardia and ventricular ectopic activity unresponsive to lidocaine. The action and effects of procainamide are similar to those of quinidine. Both decrease automaticity of ectopic foci in the atria, AV junction, bundle of His, bundle branches, and the Purkinje fibers. They both decrease conductivity through the atria, the bundle of His, and the His-Purkinje system. Conversely, conductivity through the AV node is increased by the clocking of parasympathetic activity at the AV node. Other effects include decreased atrial and ventricular excitability and a decrease in the force of ventricular contraction.

The net effect of the administration of procainamide and quinidine is the suppression of atrial, AV junctional, and ventricular ectopic activity. A decrease in heart rate and stroke volume also occurs, which may decrease cardiac output and decrease the systemic blood pressure. Thus, procainamide and quinidine are indicated in the treatment and prevention of premature ventricular contractions and ventricular tachycardia that cannot be controlled by lidocaine.

Because both drugs are very potent and can produce serious side effects if not managed closely, they are not recommended for field use. If used, procainamide is administered by continuous I.V. drip with a dose of 2 g in 500 cc D5W to yield a concentration of 4 mg/ml. Quinidine may be given intravenously or intramuscularly but is most commonly given orally in doses of 200 to 600 mg every 6 hours.

5. *Bretylium tasylate* is used for the treatment of ventricular tachycardia and ventricular fibrillation which have been unresponsive to lidocaine or procainamide therapy. Facilitation of the termination of ventricular arrhythmias by electrical shock is the major benefit derived from bretylium. At the present time, bretylium is not considered a first-line antiarrhythmic agent but is recommended if other forms of therapy have failed to control the arrhythmia.

In ventricular fibrillation, 5 mg/kg of bretylium is given as an I.V. bolus followed by electrical defibrillation. If fibrillation persists, the dose can be increased to 10 mg/kg and repeated at 15–30 minute intervals to a maximum dose of 30 mg/kg.

For recurrent ventricular tachycardia, 500 mg of bretylium should be diluted to 50 ml and a bolus of 10 mg/kg injected I.V. over an 8–10 minute period. After this loading dose has been given, bretylium can be administered at an infusion rate of 1–2 mg/minute.

6. *Propranolol* is a drug generally not recommended for field use. It is used to suppress ventricular ectopic activity and rapid supraventricular tachyarrhythmias that are unresponsive to other drug therapy.

Propranolol is a potent beta-receptor blocker. Through this mechanism, it decreases everything—automaticity in the SA node, atria, AV junction, bundle of His, bundle branches, and Purkinje fibers. It decreases conductivity through the atria and bundle of His. Propranolol also decreases the force of ventricular contraction. The net effect is a decrease in heart rate, stroke volume, and cardiac work.

Propranolol is indicated in the treatment of atrial arrhythmias, PVC's and ventricular tachycardia unresponsive to lidocaine or procainamide, and in digitalis-induced arrhythmias with rapid ventricular rates.

Because of its beta-blocking properties, propranolol is contraindicated in sinus bradycardia, second- and third-degree heart block, cardiogenic shock, and congestive heart failure. Propranolol produces bronchoconstriction and is, therefore, contraindicated in the presence of asthma and chronic obstructive pulmonary disease.

A dose of up to 1 mg of propranolol is administered I.V. slowly at a rate of 1 mg/minute and may be repeated every 5 minutes to a total dose of 5 mg. The most common side effects of propranolol are marked bradycardia and hypotension. These may be accompanied by shock, syncope, and angina. Other side effects include exacerbation of congestive heart failure with pulmonary congestion, confusion, and bronchospasm or bronchial wheezing.

7. *Digoxin* is used to decrease rapid ventricular rates in supraventricular tachyarrhythmias and to improve ventricular contractility in congestive heart failure. However, digoxin like procainamide, quinidine, and propranolol is not recommended for field use.

At therapeutic levels, digoxin slightly decreases automaticity of the SA node, slightly increases atrial excitability and conductivity, suppresses conduction of impulses at the AV node, and increases the force of ventricular contraction. The net effect of digoxin is a decrease in the heart rate, an increase in cardiac output, and an increase in cardiac work.

At dosages above therapeutic levels, digoxin increases automaticity of the SA node and ectopic foci in the atria, the AV junction, and the His-Purkinje system. In addition, excitability and conductivity in the atria and His-Purkinje system are decreased at toxic levels. Supraventricular and AV junction tachyarrhythmias, AV block, and ventricular ectopic activity may also result.

Digoxin is indicated in the treatment of congestive heart failure and of supraventricular tachyarrhythmias with fast ventricular rates such as atrial flutter, atrial fibrillation, paroxysmal atrial or AV junctional tachycardias, and PVC's caused by congestive heart failure.

Digoxin has many side effects, including cardiac arrhythmias and gastrointestinal, visual, neurologic, and endocrine disturbances. The most common arrhythmias encountered include paroxysmal atrial tachycardia with block, junctional tachycardia, and ventricular bigeminy. Gastrointestinal disturbances caused by digoxin include anorexia (loss of appetite), nausea, vomiting, and diarrhea. Visual disturbances include abnormal visual sensation such as color; especially yellow, brown, and green; seeing spots; blurred vision; and intolerance to light. Neurological disturbances include headache, fatigue, insomnia, depression, vertigo, increased irritability, and general muscular weakness. Endocrine disturbances include tingling in the breasts.

In addition to antiarrhythmic drugs, other drugs are used to treat cardiovascular disorders. These include alkalinizing agents, vasopressors, cardiotonic drugs, analgesics, tranquilizers, diuretics, and anticoagulants.

8. *Sodium Bicarbonate.* The most frequently used alkalinizing agent is sodium bicarbonate. Sodium bicarbonate is indicated in the treatment of metabolic acidosis because of hypotension, shock, or cardiac arrest. Bicarbonate is a normal extracellular fluid buffer and is described in Module III.

Sodium bicarbonate neutralizes acidosis and returns the pH toward normal. As a result, the depressed sympathetic activity returns to normal. In addition, correction of serious metabolic acidosis may be accompanied by an increase in the force of ventricular contraction. The correction of acidosis may also enhance drug treatment and direct current conversion of ventricular ectopic activity.

Sodium bicarbonate generates carbon dioxide and may cause respiratory acidosis if this gas is not being eliminated in proportion to its rate of generation.

The initial dose of sodium bicarbonate is one milliequivalent per kilogram body weight (1 mEq/kg), I.V. push, and no more than one ampule (50 mEq) every 10 minutes of continued inadequate circulation. Further administration of sodium bicarbonate must be governed by the arterial blood gas and pH measurements. If excessive amounts of sodium bicarbonate are given, the sodium load will increase the blood volume and may precipitate or worsen congestive heart failure. In addition, metabolic alkalosis will result.

9. *Epinephrine*. A cardiotonic agent increases cardiac tone. This class of drug includes sympathomimetic agents that mimic the action of the sympathetic nervous system. Epinephrine is a sympathomimetic agent used to stimulate the heart and improve the force of ventricular contraction in cardiac arrest. Epinephrine acts on both alpha and beta receptors. Beta stimulation increases automaticity of the SA node or ectopic foci in the AV junction and the His-Purkinje system. There is also an increase in the force of ventricular contraction, heart rate, stroke volume, and cardiac output. Epinephrine enhances also direct current conversion of ventricular fibrillation and acts on the alpha receptors in the arterioles. Alpha stimulation produces vasoconstriction. The net effect of the administration of epinephrine is vasoconstriction and an increase in peripheral vascular resistance. Through its effects on the alpha and beta receptors in the heart and blood vessels, epinephrine increases systolic blood pressure by increasing both cardiac output and peripheral vascular resistance.

Epinephrine is indicated in the treatment of ventricular fibrillation and asystole. It may be administered by intravenous, tracheobronchial, or intracardiac injection. When given I.V., the dose is 5–10 ml of a 1:10,000 solution and repeated approximately every 5 minutes because of the short duration of action of this drug. Injection of 10 ml of the 1:10,000 solution through an endotracheal tube promotes rapid absorption of the drug. This tracheobronchial route should be utilized when difficulty is encountered in establishing an I.V. line and is preferred over the intracardiac injection. If given by the intracardiac route, 5 ml of a 1:10,000 solution is injected. This mode of administration should be used only when other routes are inaccessible.

10. *Calcium chloride* is generally used to stimulate the heart to beat during asystole and to improve ventricular contraction during cardiac arrest. It increases automaticity in the His-Purkinje system and increases myocardial contractility. These effects combine to increase heart rate, stroke volume, cardiac output, and blood pressure.

Calcium chloride is indicated following successful termination of cardiac arrest, if sodium bicarbonate and epinephrine do not restore cardiac output (e.g., in electromechanical dissociation—EMD). It may also be used during cardiac arrest—if precordial thump, CPR, and epinephrine do not restore an electrical rhythm.

Calcium chloride enhances ventricular excitability and, thus is contraindicated in the presence of ventricular fibrillation. Calcium administration may result in ventricular arrhythmias in patients who are fully digitalized. Therefore, calcium chloride must be used with caution in patients on a digitalis preparation.

Calcium chloride is administered slowly I.V. in a dose of approximately 500 mg (5 m of 10 percent solution) and can be repeated as often as necessary at 10-minute intervals.

Calcium chloride and sodium bicarbonate should never be injected concurrently or immediately following each other. The I.V. must be flushed briefly with the I.V. fluid to avoid precipitation.

A vasopressor is used to elevate the blood pressure in the presence of shock. Some sympathomimetics are also vasopressors. These include metaraminol, norepinephrine, and dopamine.

11. *Metaraminol* acts on the alpha receptors in the arterioles to produce vasoconstriction. This increases peripheral vascular resistance and elevates the systolic and diastolic blood pressure. Metaraminol also stimulates the beta receptors in the heart and causes an increase in automaticity of the SA node, an increase in the force of ventricular contraction, and dilation of the coronary arteries. As a result, the heart rate, stroke volume, and cardiac output increase.

The administration of metaraminol is indicated in the treatment of hypotension and shock not caused by blood loss. It may also be used to terminate supraventricular arrhythmias by reflex vagal stimulation. Metaraminol is contraindicated in the presence of hypovolemic shock. Although the blood may be raised, metaraminol further decreases tissue perfusion when the blood volume is low.

Metaraminol may be given I.M., S.C., or I.V.; however, only I.V. administration is recommended in the field. When given I.V., metaraminol is administered by a continuous drip of 100 mg in 250 cc D5W regulated to infuse at the rate that maintains the systolic blood pressure between 100 and 120 mm Hg.

Side effects of metaraminol occur at doses above the recommended levels. These side effects include ventricular arrhythmias, severe hypertension, severe headaches, sweating, vomiting, and anxiety.

12. *Norepinephrine* is a vasopressor that has actions similar to those of metaraminol but is more potent. Norepinephrine acts predominately on the alpha receptors in the arterioles and the beta receptors in the heart. Alpha stimulation increases the automaticity of the SA node, increases ventricular contractility, and increases dilation of the coronary arteries. Consequently, the heart rate, stroke volume, and cardiac output increase. Norepinephrine, like metaraminol, is indicated in the presence of hypotension and shock not due to blood loss.

Norepinephine is contraindicated in the presence of hypovolemic shock.

Norepinephrine is administered I.V. by a continuous drip. The I.V. drip is prepared by adding 8 mg norepinephrine to 500 cc D5W and regulated at a rate to maintain the systolic pressure between 100 and 200 mm Hg.

Whenever possible, norepinephrine should be administered through a large vein. If the I.V. should infiltrate, tissue necrosis and sloughing will occur. Local infiltration of 5 to 10 cc of phentolamine into the affected tissues may prevent necrosis and sloughing.

Side effects of norepinephrine occur at doses above the recommended levels. These side effects include severe hypertensions, reflex bradycardia, violent headache, ventricular arrhythmias, pallor, stabbing chest pain, intense sweating (diaphoresis), vomiting, and respiratory difficulties.

13. *Dopamine* is also a vasopressor used to treat shock. At low dosage (1–2 mg/kg/min.), dopamine acts on specific dopamine receptors to cause vasodilation of the renal (kidneys) and mesenteric (intestines) vascular beds. Dopamine reduces blood flow through skeletal muscle arterioles. The net effect at these dosages is vasodilation and decreased peripheral vascular resistance.

In higher dosages (2–5 mg/kg/min.), dopamine stimulates the beta receptors in the heart to increase the force of myocardial contraction without increasing heart rate. There is a rise in the systolic blood pressure with little effect on the diastolic pressure. Rerouting of blood to vital organs prevents hypoxia in these organs. Renal blood flow increases as a result of increased cardiac output and renal vasodilation, which in turn increases urine output and sodium excretion.

At higher doses (5–10 mg/kg/min.), beta-adrenergic effects on the heart become more pronounced. There are increases in heart rate, contractility, and cardiac output. At these dosages, dopamine acts on the alpha receptors to produce vasoconstriction of arterioles.

Dopamine causes an increase in cardiac work and, thus, an increase in myocardial oxygen demand. Therefore, large doses of dopamine may produce undesirable effects in patients with cardiogenic shock. Potentially, the increased cardiac oxygen requirement may increase the size of myocardial infarction and further impair cardiac pumping.

Dopamine is administered by continuous I.V. drip. Five 200–mg ampules (1 g) of dopamine are added to 1000–ml D5W to yield a concentration of 1 mg/cc and are infused at a rate of 0.1 to 1.0 ml/min. Dopamine should not be mixed with bicarbonate, because it is inactivated in alkaline solution.

The most frequent side effects caused by the administration of dopamine are ventricular ectopic beats, tachycardia, dyspnea, nausea, vomiting, anginal pain, hypotension, and headache.

Other drugs used in cardiovascular problems include drugs to relieve pain and anxiety. Two frequently used drugs in this class are morphine sulfate, a pain reliever (analgesic), and diazepam (Valium), an anxiety-reducing drug (tranquilizer).

14. *Morphine* sulfate is a narcotic used to relieve severe pain caused by AMI and to relieve severe dyspnea caused by pulmonary edema. Morphine acts on the C.N.S. by sedating the cerebrum to alter pain perception and to decrease anxiety. Patients may state that they still have pain, but that it bothers them less. Morphine decreases peripheral vascular resistance, which causes peripheral vascular pooling. This diminishes venous return and, thus, reduces pulmonary edema. The decrease in peripheral vascular resistance also lowers blood pressure.

Morphine may be administered I.V., S.C., or I.M. I.V. administration is recommended in the field. Morphine is given in 2–5 mg doses at frequent intervals to a total of 10 mg or until the patient experiences relief from pain. The smallest possible dose that is effective should be used to avoid lowering the blood pressure excessively.

Side effects of morphine include hypotension, bradycardia, nausea, vomiting, euphoria, and constipation. Hypotension may be decreased by elevating the patient's legs; bradycardia may be corrected by administering atropine.

The major hazards of morphine administration are respiratory depression and respiratory arrest. Naloxone can be administered to improve the respiratory function.

15. *Diazepam* is indicated in the relief of tension and anxiety produced by AMI. Diazepam should be administered cautiously to pregnant women; it is contraindicated in infants. Diazepam depresses the C.N.S., producing a calming effect and amnesia.

The drug may be administered I.V. or I.M. in 5– to 10–mg doses. If given I.V., the rate should be no faster than 5 mg/min. The dose may be repeated in 1 to 4 hours.

Common side effects of diazepam include drowsiness, fatigue, lethargy, and muscle weakness. Higher levels than recommended may produce confusion, coma, hypotension, and respiratory and cardiac arrest.

In addition to digoxin and morphine sulfate, diuretics are also used in the treatment of congestive heart failure. Furosemide is a diuretic commonly used to reduce peripheral and pulmonary edema accompanying congestive heart failure. It is contraindicated in pregnant women and in women of childbearing age.

16. *Furosemide* exerts its major effect by blocking the reabsorption of sodium in the tubules of the kidneys. Sodium chloride and potassium are excreted, increasing water loss. Through these effects, furosemide reduces extracellular fluid volume and decreases both peripheral and pulmonary edema.

In severe congestive heart failure, 40 mg of furosemide is injected slowly I.V. over 1 to 2 minutes. In milder congestive heart failure, 40 mg of furosemide may be given I.M. or I.V.

Furosemide is a potent diuretic that if given in excessive amounts can lead to profound diuresis with water and electrolyte (especially potassium) depletion. The patient will thus become dehydrated. Other common side effects are postural hypotension, weakness, flushing, dizziness, blurred vision, allergic reactions, nausea, and vomiting.

## Application of Monitoring Electrodes

Accurate interpretation of the cardiac rhythm requires proper application of the electrodes in order to minimize artifact. To accomplish this, the paramedic should:

- Apply silver plates or clamp electrodes to the inner surfaces of the arms and legs. These areas are preferable because of the relative absence of hair. Place the electrodes as proximally on the arms and legs as possible to minimize movement of the electrode sites.
- Apply stick-on disk electrodes to the chest. The chest hair may need to be shaved to allow the disks to adhere properly. The precordium of the patient must be left adequately exposed to allow application of defibrillation paddles if necessary.
- Rub the electrode site vigorously with an alcohol swab to remove oil and dead tissue from the surface of the skin and permit the skin to dry.
- Apply conductive electrode paste or jelly to the electrode and attach electrodes to the prepared sites. For continuous monitoring, EKG leads I, II, or $MCL_1$ may be used. To obtain these leads, three electrodes are used: one negative, one positive, and one ground. The ground electrode may be placed anywhere on the body. For lead I, the negative electrode is placed on the right arm or right upper chest, and the positive electrode on the left arm or left upper chest. For lead II, the negative electrode is placed on the right arm or right upper chest, and the positive electrode on the left leg, left lower chest, or sternum. For lead $MCL_1$, the negative electrode is placed on the left upper chest, and the positive electrode in the right fourth intercostal space.
- Attach the electrodes to the cable.
- Assess the signal.

A poor signal is usually caused by poor electrode contact—for example; dirty, oily skin, excessive hair, dirty electrodes, dried conduction paste, or improperly applied disks. A loose or dislodged electrode will also produce a poor signal. If patient movement or muscle tremors can be ruled out as the cause of the poor signal, then the status of the equipment must be checked. A broken electrode wire, a broken cable wire, broken connectors, and faulty grounding all can cause a poor EKG signal.

In emergency situations, such as cardiac arrest, the paddles of most defibrillatory monitors can be used for immediate detection of arrhythmias. To do this the paramedic should:

- Bare the patient's chest.
- Apply electrode paste or saline pads to the paddles. If saline pads are used, they should not be so waterlogged that saline will ooze all over the chest.
- Apply the positive (red) paddle below the patient's left nipple and the negative (black) paddle on the upper right chest, at the junction of the sternum and right clavicle.
- Press the paddles firmly on the chest and read the rhythm off the oscilloscope.

## Defibrillation

Defibrillation should be accomplished as soon as possible in ventricular fibrillation, because the possibility of success declines rapidly with time. Defibrillation is unlikely to be successful in the anoxic myocardium, and in arrest secondary to hypoxia (drowning, suffocation, "cafe coronary," drug overdose). Therefore, basic life support must be performed first to relieve the anoxia.

To defibrillate, the paramedic should turn the synchronize button on the machine to the "off" position and turn the main power switch on. The energy level should then be set to the maximum output and the paddles should be charged. Electrode paste or saline pads should be applied to the paddles; this will reduce the resistance of the patient's skin to the electrical current. Without the electrode paste or saline pads, the energy will be delivered mostly to the skin itself causing skin burns without effectively delivering energy to the heart.

Saline pads are advantageous, because they do not leave a slippery residue on the chest, which makes subsequent cardiac compression difficult. The pads must be well soaked, but not so wet that they ooze saline all over the chest. Alcohol-soaked pads should not be used, because they will ignite into flames when electrical current passes through them. If electrode paste is used, it should be squeezed generously onto the paddles and rubbed into the skin with the paddles. Whichever method is chosen, the paramedic should take care to prevent contact (bridging) between the two conductive areas. If the saline or paste from one paddle comes in contact with that from the other paddle, the electrical current will simply arc or pass along the skin from one paddle to the other. Skin burns will occur and no effective current will reach the heart.

The paddles are placed in such a manner that one is just to the right of the upper sternum below the right clavicle and the other just below and to the left of the left nipple. A firm pressure (20 to 25 pounds) is exerted on each paddle to make good skin contact. Inadequate contact results in burns and in ineffective countershock. An alternate method to the above is to place one paddle anteriorly over the precordium and the other posteriorly behind the heart.

When the paddles are in place, the arrhythmia should be verified; if ventricular tachycardia or ventricular fibrillation is present, the paramedic should charge the defibrillator to 200–300 joules. When ready, the paramedic should say "stand back" to make sure no one, including the operator, is touching the patient or stretcher. The defibrillator can then be fired by pressing the button on each handle at the same time. If current reaches the patient, there will be contraction of the chest and other muscles. If this does not occur, the defibrillator must be checked to be sure that the synchronizing circuit is off and the battery is charged.

Immediately after the defibrillating current has been delivered, the paramedic should observe the monitor via the paddles. If a regular rhythm is present, the patient's pulse should be checked immediately to determine whether the rhythm is associated with adequate cardiac output. If the pulse is absent, resume CPR no matter what the monitor shows. It should take no more than 10 seconds to check the monitor and pulse after countershock. The entire sequence—application of paddles, shock, checking the monitor, and checking the pulse—should take no more than 15 to 20 seconds. If the initial defibrillation attempt is unsuccessful, a second attempt should be made using 200–300 joules of delivered energy. If the second attempt is unsuccessful, resume CPR while appropriate cardiac medication is ordered and administered.

## Cardioversion

Cardioversion is an elective procedure using the direct current defibrillator to terminate arrhythmias other than ventricular fibrillation. In cardioversion, as opposed to defibrillation, the current is synchronized with the electrocardiogram so that the charge will not be delivered during the vulnerable period (downslope of the T wave). Emergency cardioversion is indicated for rapid ventricular and supraventricular rhythms associated with inadequate cardiac output. This includes ventricular tachycardia, atrial flutter, or atrial fibrillation with a rapid ventricular response. Cardioversion probably should not be used to convert rapid rhythms known to be caused by digitalis overdose.

In the field, emergency cardioversion generally will be performed on the unconscious or stuporous patient; therefore, no premedication is necessary. In the hospital, cardioversion at times may be performed electively on conscious patients who are first sedated with diazepam or similar agent.

To perform emergency cardioversion, the paramedic should:

- Turn the synchronize button on the machine to the "on" position and turn the main power on. The monitoring electrodes must be placed so as to obtain a tall R wave. The defibrillator senses the R and will deliver the shock on the slope of the R.
- Set the energy level as ordered by the physician. Energy levels required for cardioversion vary depending on the type of arrhythmia present. Ventricular tachycardia, for example, can often be converted with energy levels as low as 20 watt-seconds. In emergencies, however, if an initial attempt to convert a rapid rhythm with low energy levels fails, the setting should be turned up to the maximum output of the machine and the shock should be repeated.
- Prepare and apply the paddles as described for defibrillation.
- Clear the area by commanding "Everyone off!"
- Depress the firing buttons and keep them depressed until the synchronizer fires the machine. This may take a few seconds, because the charge is synchronized to fire 10 milliseconds after the peak of the R wave.
- If ventricular fibrillation results, the paramedic should immediately
  —Recharge the defibrillator to the maximum energy setting
  —Turn the synchronizer circuit to the "off" position
  —Shock again.

## Rotating Tourniquets

Rotating tourniquets are used in the treatment of acute pulmonary edema. Tourniquets reduce circulating blood volume by pooling the blood in the extremities. To apply rotating tourniquets, assess baseline quality of pulses in all four extremities. Next apply tourniquets to three of four extremities tightly enough to occlude venous return but not so tightly as to occlude arterial inflow. Check arterial blood flow by palpating a distal pulse. The tourniquets are then rotated every 10 minutes. For example:

| Time | Tourniquets on |
|---|---|
| Zero | Left arm, both legs. |
| 10 minutes | Both legs, right arm. |
| 20 minutes | Right leg, both arms. |
| 30 minutes | Both arms, left leg. |

At the hospital, when the tourniquets are removed, each tourniquet is removed at 5-minute intervals. If all three tourniquets were removed simultaneously, the sudden increase in venous return would cause an exacerbation of the pulmonary edema.

## Carotid Sinus Massage

Carotid sinus massage is a form of vagal stimulation. Carotid sinus massage is sometimes used in an attempt to convert paroxysmal tachyarrhythmias associated with hypotension or a decreased level of consciousness. To perform carotid sinus massage, the paramedic should:

- Monitor the patient's cardiac rhythm closely throughout the procedure.
- Assemble all equipment needed for resuscitation in case of cardiac arrest.
- Gently palpate each carotid artery separately to assure that pulses are equal on both sides. (If one carotid pulse is absent or weak, do not perform this procedure.) The carotid arteries are below the angle of the jaw and high up in the neck.
- The patient should be lying supine with the neck extended. The patient's head should be turned slightly away from the side to be massaged. (Start with the right side.)
- Place the index and middle finger over the carotid artery firmly and massage the carotid sinus. Maintain pressure and massage no longer than 15 to 20 seconds, always watching the monitor. Stop immediately when the heart rate slows. If massage of the right carotid sinus is unsuccessful, wait 2 to 3 minutes and try the same procedure on the left side. Again, do not massage for more than 15 to 20 seconds and stop immediately if the heart rate slows.
- Never massage both carotid sinuses at the same time. Carotid sinus massage is not an innocuous procedure. Asystole or ventricular irritability can result. Carotid sinus massage does interfere with cerebral circulation and may cause syncope, seizures, or hemiplegia. Effective carotid sinus massage stimulates the parasympathetic nervous system and produces hypotension, nausea, vomiting, and bradycardia.

## Intracardia Injections

If an I.V. cannot be established quickly during cardiac arrest, epinephrine can be administered directly into the heart by intracardiac injection. This technique has no advantage over the administration of epinephrine through the endotracheal tube and actually has many hazards. These hazards include inadvertent injection into the heart wall, pneumothorax, and cardiac tamponade. In addition, ventilations and compressions have to be interrupted during intracardiac injections. Therefore, the I.V. or endotracheal route is preferred for administration of epinephrine.

If an intracardiac injection is ordered, the paramedic should:

- Connect a long (spinal) 20- to 22-gauge needle to a syringe of epinephrine, if it is not already attached (as it is in many pre-filled syringes).
- Locate the fourth or fifth left intercostal space, approximately 1.5 inches to the left of the sternal border. Clean the area with an alcohol or iodine swab if available.
- Insert the needle at a right angle to the chest wall, maintaining a slight pull on the plunger.
- When blood is freely aspirated into the syringe, indicating that the tip of the needle has entered the ventricular cavity, inject the contents of the syringe as a bolus.
- Rapidly withdraw the needle and immediately resume external cardiac compressions.

## Mechanical CPR Devices

Different mechanical adjuncts are available for artificial circulation. The purpose of such adjuncts is to reduce or eliminate operator fatigue and to decrease the number of persons needed to perform CPR. The mechanical CPR devices are also especially suited to use for long-distance transport during which CPR must be performed.

The safety and effectiveness of these devices, however, have not been proven. Their use presupposes extensive training and frequent team drills to assure correct application, coordination of team effort, and efficient assembly time. These devices should never be used to initiate CPR. Resuscitation should always be started manually. Positioning of adjunctive devices should not interrupt CPR for more than 15 to 20 seconds.

There are two general categories of mechanical CPR devices: (1) manually operated cardiac presses and (2) automatic, gas-powered compressors. The cardiac press is a hinged, manually operated chest compressor that usually provides an adjustable stroke of 1.5 to 2.0 inches. The following steps should be taken when using a cardiac press:

- CPR is initiated by manual methods. The first rescuer continues one-person CPR.
- The second rescuer slides the backboard of the press under the patient's back and places the frame in the position holes.
- The adjustment knot is loosened and the plunger is positioned centrally on the lower half of the sternum. The adjustment knot is then retightened.
- Cardiac compressions are then applied by the second rescuer who pushes the handle of the press down with a brisk stroke; the handle is then released, allowing the press to return to its "up" position. Compressions are performed once per second.
- The first rescuer ventilates the patient after every fifth compression. The paramedic must be careful that the compressor does not shift position and apply force over the ribs or abdomen. The tightening knob should be checked periodically; if it becomes loose, the plunger will not deliver an adequate compression.

The automatic, gas-powered compressor delivers compression via a plunger mounted on a backboard and driven by compressed oxygen. The same oxygen source may be used to provide oxygen-enriched positive-pressure ventilation with an inspired oxygen content of up to 80 percent. When used in an ambulance, the device should be secured with a strap to the patient's chest to reduce shifts in plunger position when the vehicle is moving. Table 6.5 shows the activities of both rescuers necessary for performing CPR with the device.

### Table 6.5

**Activities for Performing CPR With an Automatic, Gas-Powered Compressor**

| First Rescuer | Second Rescuer |
|---|---|
| Initiate CPR by manual methods. | Secure equipment. |
| Roll patient on the side....... | Position base plate under patient so that lower part of patient's sternum is over center of plate. |
| Return patient to supine position. | Mount, position, and place in operation automatic chest compressor. |
| Resume CPR ...................... | Set up ventilation equipment. |
| Ventilate patient after every fifth compression. | |
| Switch to ventilation equipment. | |

The paramedic must check to be sure the chest rises. Carotid pulse with compressions should be checked. Careful monitoring is required to insure that the plunger does not slip out of position. If the oxygen power source runs out, manual CPR methods must be resumed.

## Glossary

**advanced life support:** The basic life support plus definitive therapy; the use of invasive procedures or drugs.

**angina:** Any disease marked by attacks of choking or suffocation.

**anorexia:** A lack of appetite.

**aorta:** The largest artery in the body; originates at the left ventricle.

**arteriosclerosis:** A generic term for several conditions that cause the walls of the arteries to become thickened, hard, and inelastic; hardening of the arteries.

**artifact:** Any artificial product; used to refer to "noise" or interference on electronic equipment.

**asystole:** A faulty contraction of the ventricles of the heart.

**atherosclerosis:** A common type of arteriosclerosis that affects the coronary and cerebral arteries.

**atrial fibrillation:** An arrhythmia characterized by discharge of multiple atrial ectopic foci and an inconsistently irregular ventricular rhythm.

**atrial flutter:** A cardiac arrhythmia caused by an abnormal atrial excitation.

**atrioventricular (AV) node:** A structure located in the atrioventricular junction; slows conductions through the atrioventricular junction.

**atrium:** The thin-walled chamber of the heart; the right atrium receives venous blood from the vena cava; the left atrium receives oxygenated blood from the pulmonary veins.

**automaticity:** The ability of pacemaker sites, within the human electrical system, to initiate excitation impulses spontaneously.

**basic life support:** Maintaining the ABC's (airway, breathing, and circulation) without adjunctive equipment.

**blocker:** A drug that counteracts or inhibits the action of another drug or agent (such as atropine).

**bundle of His:** The portion of the electrical conduction system located in the interventricular septum that conducts the excitation impulse from the atrioventricular junction to the right and left bundle branches.

**capillary:** Any one of the extremely narrow blood vessels that form a network between arterioles and venules; also, a small lymphatic duct that conveys blood and nutrients to the tissues and wastes from the tissues to the blood.

**cardiac output:** The amount of blood pumped out by the heart per minute.

**cardioversion:** An application of direct current electrical shock to the chest wall to convert various tachyarrhythmias to normal sinus rhythm; usually the electrical shock is synchronized to the R wave.

**complete heart block:** A third-degree heart block; complete absence of conduction of the excitation impulse from the atria to the ventricles; the disturbance causing the block can occur in the AV junction, AV node, bundle of His, or the bundle branches; an ectopic focus below the block becomes the pacemaker for the ventricles, and the atrial and ventricular contractions become dissociated.

**congestive heart failure (CHF):** Excessive blood or fluid in the lungs or tissues caused by the failure of the ventricles to pump blood effectively.

**contractility:** The ability of the heart muscle to contract when it is depolarized by an excitation impulse.

**coronary artery:** One of the two arteries arising from the aorta that arches down over the top of the heart; supplies the heart muscle with blood.

**cyanosis:** A blueness of the skin due to insufficient oxygen in the blood.

**defibrillation:** The application of an unsynchronized direct current electrical shock to terminate ventricular fibrillation.

**depolarization:** The process of discharging resting cardiac muscle fibers by an electrical excitation impulse, thus causing the muscle fibers to contract.

**diaphoresis:** A condition of profuse perspiration.

**diastole:** The interval in the normal heart cycle when the ventricles relax and fill with blood.

**ectopic focus:** Located away from the normal position.

**edema:** A condition in which fluid escapes into body tissues from vascular or lymphatic spaces and causes local or generalized swelling.

**electromechanical dissociation:** A condition in which EKG complexes are present without effective cardiac contractions.

**epistaxis:** A nosebleed.

**first-degree AV block:** The first of three recognized degrees of severity of heart block; see complete heart block and second-degree AV block.

**hypertension:** High blood pressure, usually in reference to a diastolic pressure greater than 90 to 95 mm Hg.

**infarction:** The death (necrosis) of a localized area of tissue due to the cutting off of its blood supply.

**ischemia:** A reduced blood flow into a portion of tissue due to a narrowing or occlusion of the artery to that area, thereby producing tissue anoxia.

**isoelectric line:** The baseline of the EKG.

**Mobitz Type I (Wenckebach):** A type of second-degree heart block; see complete heart block and second-degree AV block.

**Mobitz Type II:** A type of second-degree heart block; see complete heart block and second-degree AV block.

**myocardium:** The cardiac muscle.

**necrosis:** A death of an area of tissue, usually caused by the cessation of blood supply.

**normal sinus rhythm:** The normal rhythm of the heart: The excitation impulse arises in the SA node, travels via internodal pathways to the AV junction, then down the bundle of His, the bundle branches, and then into the Purkinje network.

**pacemaker:** The specialized tissue within the heart that initiates excitation impulses; an artificial device used to stimulate the heart to beat when the electrical conduction system of the heart is malfunctioning; a pacemaker consists of an implanted or external battery-operated pulse generator and a wire that delivers the impulse to the ventricles.

**PAC:** Abbreviation for premature atrial contraction.

**palpitation:** A sensation felt under the left breast when the heart "skips a beat" that is caused by premature ventricular contractions.

**parasympathetic nervous system:** A subdivision of the autonomic nervous system involved in control of involuntary functions, mediated largely by the vagus nerve through the chemical acetylcholine.

**pericardium:** The double-layered sac containing the heart and the origins of the superior vena cava and pulmonary artery.

**P–R interval:** The period of time between the onset of the P wave (atrial depolarization) and the onset of the QRS complex (ventricular depolarization), signifying the time for atrial depolarization and passage through the AV junction.

**pulmonary artery:** The major artery leading from the right ventricle to the lungs.

**pulmonary edema:** The condition of the lungs when the pulmonary vessels are filled with exudate and foam, usually secondary to left heart failure.

**pulmonary vein:** One of the veins that carries oxygenated blood from the lungs to the left atrium.

**Purkinje fibers:** The modified cardiac muscle fibers that form the terminal part of the conducting system to the heart.

**PVC:** Abbreviation for premature ventricular contraction.

**P wave:** The first wave of the P–QRS–T complex, representing depolarization of the atria.

**QRS complex:** The deflections of the EKG produced during ventricular arrhythmias.

**rales:** An abnormal breath sound produced by the flow of air through alveoli and bronchioles when they are constricted by spasm or filled by secretions.

**refractory period:** A period of relative relaxation of a muscle during which excitability is depressed. If stimulated, it will respond, but a stronger stimulus is required and response is less.

**repolarization:** The electrical process of recharging depolarized muscle fibers back to the resting state.

**R–R interval:** A period of time between the onset of one QRS complex and the onset of the succeeding QRS complex.

**second-degree AV block:** The second of three recognized degrees of severity of heart block; see complete heart block and first-degree AV block.

**septum:** A dividing wall or partition, usually separating two cavities.

**sinoatrial (SA) node:** The dense network of Purkinje fibers of the heart's electrical system, located in the junction of the right atrium and vena cava.

**sinus arrest:** The cessation of pacemaker activity of the sinoatrial node.

**sinus arrythmia:** An irregularity of the heartbeat caused by interference with impulses from the SA node.

**sinus bradycardia:** A sinus rhythm with a rate of less than 60 beats per minute.

**sinus tachycardia:** A sinus rhythm with a rate of greater than 100 beats per minute.

**stroke volume:** The amount of blood pumped forward by the heart each time the ventricles contract.

**ST segment:** The interval between the end of the QRS complex and the beginning of the T wave; often elevated or depressed with respect to the isoelectric line when there is a significant myocardial ischemia.

**supraventricular tachycardia:** A rapid tachyarrhythmia with the pacemaker originating above the ventricles.

**sympathetic nervous system:** A subdivision of the autonomic nervous system that governs the body's "fight or flight" reactions and stimulates cardiac activity.

**syncope:** A faint; a brief period of unconsciousness caused by an inadequate blood flow to the brain.

**systole:** The period during which the ventricles contract.

**tachypnea:** An excessively rapid rate of respiration (over 25 per minute in adults).

**tamponade:** A condition resulting from excess fluid accumulation in the pericardium; may result from pericarditis or injuries to the heart with an accumulation of blood.

**third-degree AV block:** See complete heart block and first- and second-degree AV block.

**T wave:** An upright, flat, or inverted wave following the QRS complex that represents ventricular repolarization.

**vagus:** The tenth cranial nerve; chief mediator of the parasympathetic system.

**vasovagal:** Pertaining to the vagus nerve and blood vessels.

**vena cava:** The two largest veins of the body returning blood to the right atrium.

**ventricles:** The thick-walled, muscular chamber in the heart that receives blood from the atrium and forces blood into the arteries.

**ventricular fibrillation:** A rapid, tremulous, and ineffectual contraction of the cardiac ventricles; cardiac arrest.

**ventricular tachycardia:** A serious cardiac arrhythmia with rapid regular, or slightly irregular, heartbeats.

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## Module VII.
# Central Nervous System

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# Module VII.
# Central Nervous System

## Unit 1. Anatomy and Physiology

The nervous system is made up of the brain and spinal cord; these combine to form the central nervous system (CNS), autonomic nervous system, and peripheral nervous system. This chapter primarily discusses the anatomy and physiology of the CNS, but also includes brief discussions of the autonomic and peripheral nervous systems; assessment of the patient with possible neurological injury; the pathophysiology of neurological problems; and management techniques.

### Nerve Cells

The nerve cell, or neuron, is the basic unit of the nervous system. Each neuron is composed of a cell

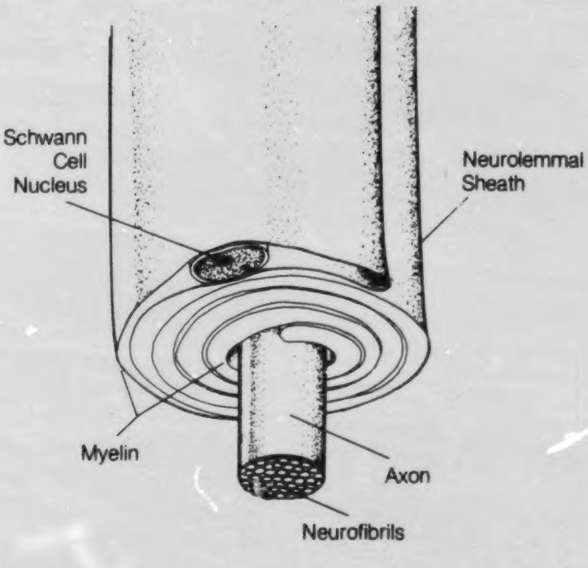
Schwann
Cell
Nucleus
Neurolemmal
Sheath
Myelin
Axon
Neurofibrils

**Figure 1. Myelinated Axon**

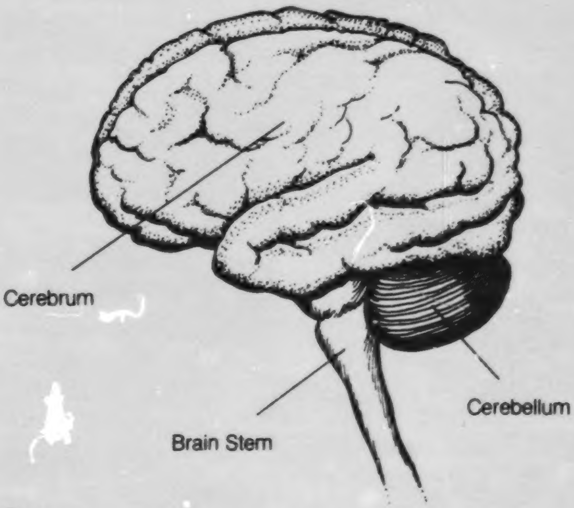
Cerebrum
Cerebellum
Brain Stem

**Figure 2. Divisions of the Brain**

238

body, which contains the nucleus of the nerve cell; dendrites, which carry impulses to the cell body; and axons, which carry impulses away from the cell body. Collections of cell bodies appear gray and therefore are referred to as "gray matter." Axons are often covered with a white myelin sheath, and areas of the nervous system that contain myelinated axons are called "white matter." Figure 7.1 shows myelinated axons.

Impulses are transmitted along nerves through a process that is part-chemical and part-electrical. It may be helpful to think of the nerves as "wires," surrounded by myelin "insulation." Nerve cells can receive impulses (excitability), conduct them (conductivity), and transmit them to a second cell (transmission). Impulses travel from the dendrites to the cell body and then from the cell body down the axon. When an impulse reaches the end of the axon, it is transmitted to a second cell across a junction; this junction is called a synapse. The second cell may be another nerve cell, a muscle cell, or a gland cell.

Unlike excitability and conductivity, which are electrical in nature, transmission of impulses from one nerve cell to another is chemical. The chemical released by the axon crosses the synapse to excite the second cell. Some drugs and poisons can block this synaptic transmission and prevent excitation of the second cell. Others can lead to a buildup of the chemical transmitter and excess excitation of the second cell.

## Brain

The brain is a complex collection of nerve cells and specialized supporting cells, located in the skull. A very soft organ, the brain is richly supplied with blood vessels; these characteristics make the brain uniquely susceptible to injury. Althought the skull can protect the brain from external injury because of its rigidity and hardness, these same qualities can in some cases injure the brain. In some ways, the brain behaves like a sponge inside a steel case—it cannot expand inside the rigid skull. Therefore, a swelling of the brain or accumulation of blood inside the skull compresses the brain and increases the pressure inside the skull. This pressure (increased intracranial pressure) causes changes that interfere with brain functioning. Further, because the skull is hard, both the brain and the blood vessels on the brain's surface may be damaged if they strike the skull's inner surface. This condition can occur when the head is struck directly or when it is rapidly accelerated or decelerated. The phenomenon of "seeing stars" when struck on the back of the head is due to the occipital lobe of the brain (the part that controls vision) banging against the back of the skull.

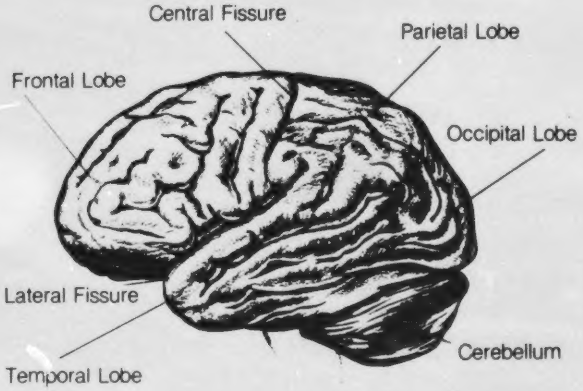

**Figure 3. Cerebral Lobes Divided by Fissures'**

The brain is divided into three main parts: the cerebrum, cerebellum, and brain stem (see Fig. 7.2). The cerebrum is the largest part of the brain, occupying the top and front of the skull; it is divided from the front to the back of the skull into left and right cerebral hemispheres. The cerebral cortex is the gray, outer surface layer of the cerebral hemispheres. This thin layer, 2 to 5 millimeters (mm) thick, contains nerve cell bodies. Each cerebral hemisphere is further divided into four lobes—frontal, temporal, parietal, and occipital—named according to the overlying skull bones. These lobes are separated from each other by fissures, as shown in Figure 7.3.

The brain is suspended inside the skull by ligaments, which function to prevent undue motion. The ligament in the midline is called the falx cerebri. Another ligament, the tentorium cerebelli, runs across the roof of the posterior fossa.

Each nerve cell in the cerebral cortex (cortical nerve cell) has a specialized function, and groups of these cells that perform related functions are located in different areas of the brain. These areas are given functional names but also may be referred to by their anatomic location. It is important for you to know these areas because damage to each area, such as that caused by trauma and stroke, causes specific clinical signs and symptoms. Because of its location in the upper front part of the skull, the cerebrum is more subject to injury than are other parts of the CNS.

Damage to the motor cortex, which is located in the frontal lobe, causes weakness or paralysis on the opposite side of the body because many nerve fibers from the cortex are crossed in the brain stem and spinal cord. The right side of the brain controls the left side of the body; the left side of the brain controls the right side of the body (see Fig. 7.4). The rest of the frontal lobe is involved in the higher mental processes of judgment, foresight, and perseverance. People with damage to this area often have difficulty making appropriate judgments.

In most people, speech is controlled by a small area of the left temporal lobe. Damage to this area causes a variety of difficulties with speech, ranging from

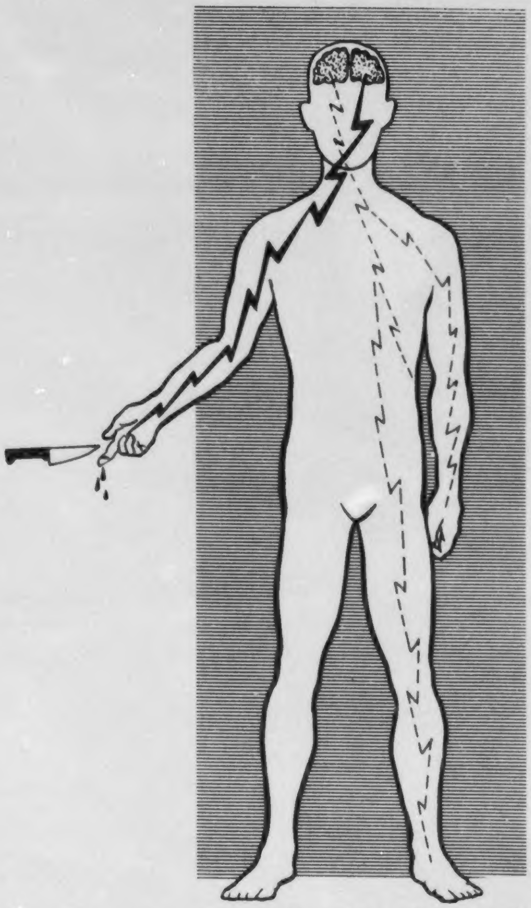

**Figure 4.** How the Left Brain Controls the Right Body

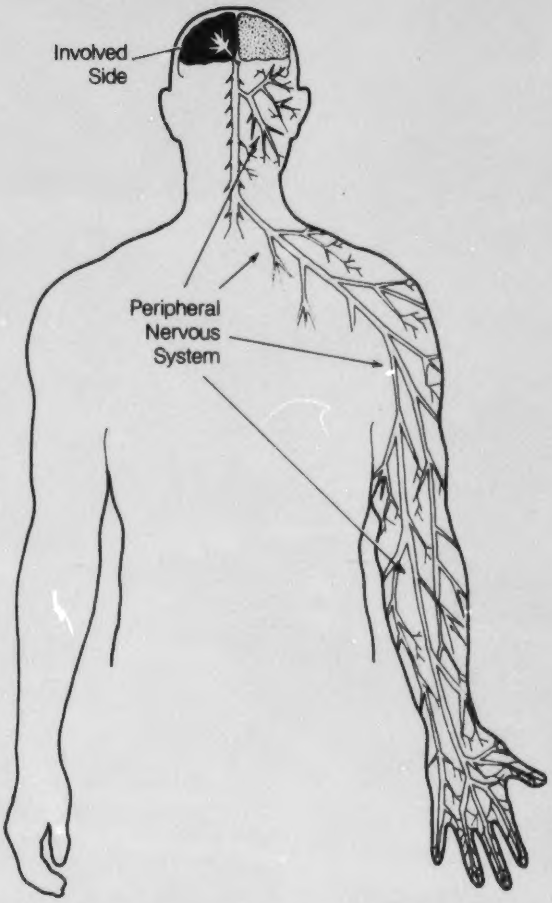

**Figure 5.** How the Sensory Nerves are Connected to Opposite Side of Brain

inability to find the correct word to total inability to speak. Hearing is controlled by the auditory cortex, located in the superior temporal lobes. Visual sensation is located in the occipital cortex in the posterior part of the cerebrum.

Other types of sensory information (touch, pain, temperature, vibration, and position sense) are received and processed by the sensory area in the parietal lobe. The crossed relationship between the brain and the body also applies to the transmission of sensory information (see Fig. 7.5). For example, the sensation of pain caused by a pin sticking the right hand is perceived by the left side of the brain. Conversely, damage to the left sensory cortex will cause a loss of perception of the right side of the body.

The cerebellum is the second major area of the brain. It is located in the lower back, or inferoposterior, part of the skull. Like the cerebrum, the cerebellum is divided into two hemispheres; it has a thin covering of gray matter over a core of white matter. The functions of the cerebellum are not as well localized to specific areas as cerebral functions are. In general, the cerebellum maintains posture and balance and coordinates skilled voluntary muscle movements. Damage to the cerebellum causes difficulties in balancing and coordination. These difficulties are most noticeable when the injured person tries to walk. Because of its location in the back of the skull, the cerebellum rarely is injured except by direct trauma to this area.

The brain stem, located at the base of the brain (see Fig. 7.2), is the third major part of the brain. It contains nerve tracts, which are functional units formed by groups of axons that carry impulses to and from the brain and the spinal cord. These structures also contain groups of nerve cell bodies (nuclei) that control various body functions. The medulla, the part of the brain stem located just above the spinal cord, has centers critical to the maintenance of vital bodily functions such as respiration, heart rate, and blood pressure. Damage to these centers, or interference with their functioning by certain drugs, causes a variety of cardiorespiratory derangements, from a slowing of the heart rate (bradycardia) to cardiopulmonary arrest.

Other centers in the brain stem control the muscles of the eyes, throat, and face and receive sensory information from these areas. From these centers, or nuclei, nerves run through different bony canals to the facial structures. Damage to the facial nerve, which can be caused by a skull fracture, will paralyze some of the

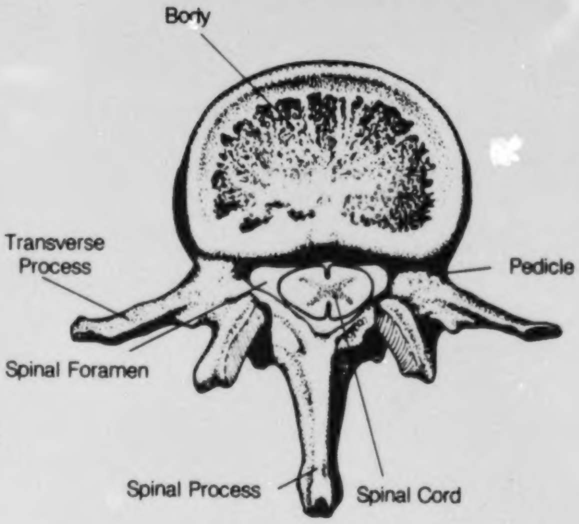
Body
Transverse Process
Pedicle
Spinal Foramen
Spinal Process
Spinal Cord

**Figure 6. Spinal Vertebra in Cross-Section**

facial muscles. Similarly, damage to the oculomotor nerve will prevent the pupil on the damaged side of the body from responding to light.

## Spinal Cord

The spinal cord is the second major part of the CNS. Like the brain, the spinal cord is protected by a bony structure, the spine. Each section (vertebra) of the spine contains an anterior bony vertebral body to support the body's weight and a posterior bony ring (neural arch) to protect the spinal cord, as shown in Figure 7.6. The spinal canal formed by the neural arch is 15 mm in diameter; inside the canal, the spinal cord is about 10 mm in diameter. Therefore, displacement of a vertebra by only 5 mm in any direction may injure the spinal cord and cause paralysis.

The spinal cord has a gray-matter core surrounded by a layer of white matter. The gray matter contains cell bodies; the white matter contains nerve tracts which connect the brain with the rest of the body. Three important tracts are shown in Figure 7.7. They are (1) the posterior column, which mediates position and vibratory sense, (2) the lateral spinal thalmic tract, which mediates pain and temperature sensation, and (3) the cortical spinal tract, which controls muscle movement. Damage to these tracts can be determined by testing position sense, pain sensation, and the ability to move the extremities.

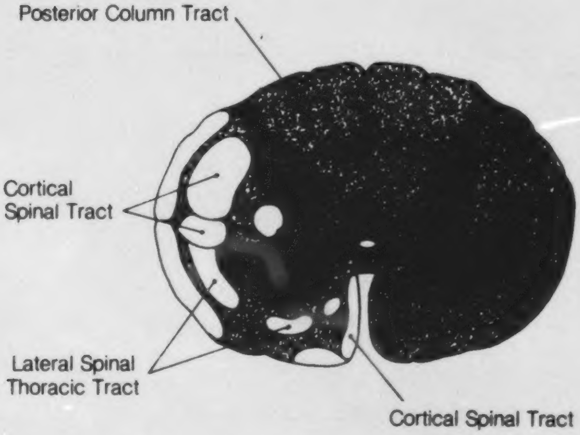
Posterior Column Tract
Cortical Spinal Tract
Lateral Spinal Thoracic Tract
Cortical Spinal Tract

**Figure 7. Three Tracts of the Spinal Cord**

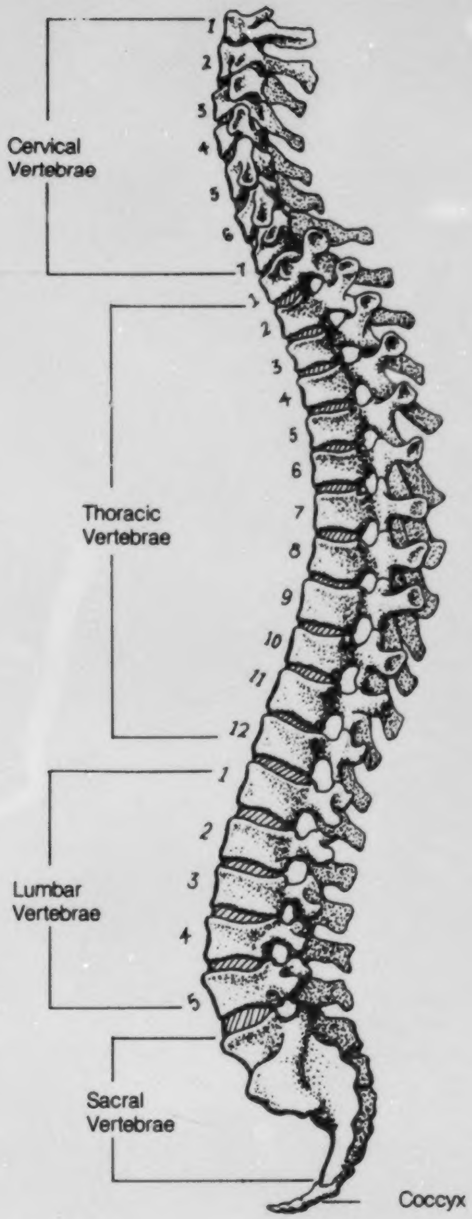
Cervical Vertebrae
1
2
3
4
5
6
7
Thoracic Vertebrae
1
2
3
4
5
6
7
8
9
10
11
12
Lumbar Vertebrae
1
2
3
4
5
Sacral Vertebrae
Coccyx

**Figure 8. Five Divisions of the Spine**

The spinal cord (see Fig. 7.8) can be divided into five main areas: cervical, thoracic, lumbar, sacral, and coccygeal (tailbone). In each section of the cord, nerve cells control motor function and sensation for specific parts of the body. At each level of the cord, bundles of nerve fibers join to form nerve roots that leave the

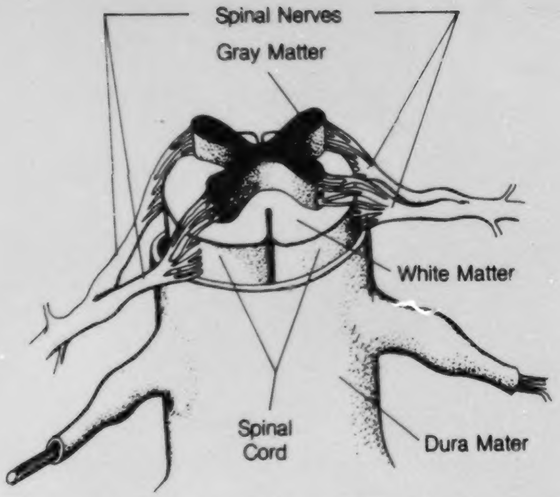

**Figure 9.** **Bundles of Nerve Fibers Joining Nerve Roots**

front and back sides of the spinal cord and then join to form peripheral nerves (see Fig. 7.9). Nerve roots in different areas control specific functions. Inability to move the shoulder, for example, indicates injury to the fifth cervical nerve root (C5). The following list gives other important relationships between nerve roots and the function of various body structures:

- Cervical
  - —Shoulder girdle (C5)
  - —Elbow flexion (C5, C6)
  - —Elbow extension (C6, C8)
  - —Wrist movement (C6, C7)
- Thoracic
  - —Thoracic region movement and sensation (T4 through T10)
  - —Sensation at the nipple level (T4)
  - —Sensation at the umbilicus (navel) level (T10)
- Lumbar
  - —Hip flexion (L2, L3)
  - —Hip extension (L4, L5)
  - —Knee extension (L3, L4)
- Sacral
  - —Knee flexion (L5, S1)
  - —Ankle movement (S1, S2)
  - —Toe movement (L5, S1, S2)

Another way of assessing possible damage to specific nerve roots is to test skin sensation in different areas. Each nerve root has cutaneous (skin) nerves which supply a given area. The area supplied by cutaneous nerves from a single nerve root is called a dermatome (see Fig. 7.10). These cutaneous nerves are part of the peripheral nervous system, which is discussed in the following section.

## Peripheral Nervous System

The peripheral nervous system is complex. Branches from the spinal nerves join together with branches from other spinal cord segments to form large bundles or plexuses. These plexuses divide further to form the peripheral nerves that run to the muscles, skin, and other structures in the extremities. The peripheral nerves may be injured by fractures or lacerations of the extremities, which may cause local muscular paralysis and loss of sensation.

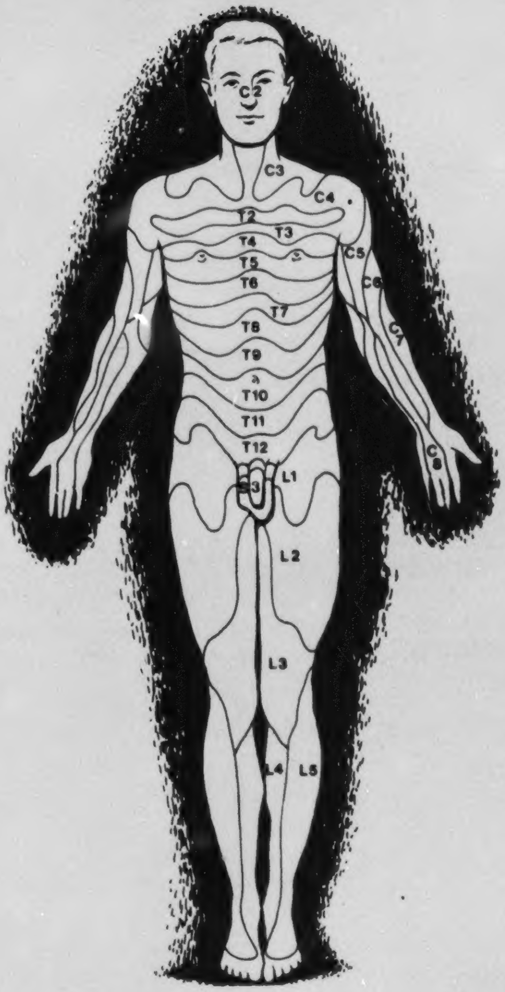

**Figure 10.** **Dermatome in Cross-Section**

There is a group of large nerves in the base of the neck and armpit; this is the brachial plexus. Branches of the brachial plexus innervate the arm and shoulder. Five major nerves branch from the brachial plexus:

- Axillary nerve—The axillary nerve supplies the deltoid muscle and skin of the shoulder.
- Musculocutaneous nerve—The musculocutaneous nerve descends laterally to supply the biceps muscle and ends in a cutaneous sensory nerve in the forearm.
- Radial nerve—The radial nerve branches off to the arm and forearm muscles, to the skin of the posterior arm, and to the posterior forearm. When the radial nerve is damaged, motion of and sensation in the thumb are lost.

- Superficial radial nerve—The superficial radial nerve is a cutaneous nerve that innervates the skin of the lateral posterior forearm and lateral posterior hand.
- Deep radial nerve—The deep radial nerve innervates the skin and the muscles of the ulna, which is the long bone in the forearm, and the hand. Because the ulnar nerve crosses the outer part of the elbow, it can be damaged in injuries to this joint. Such injuries cause sensorimotor loss in the little finger.
- Median nerve—The median nerve innervates muscles of the forearm and hand, the skin of the thumb, the first three fingers, and the radial side of the palm.

The lumbosacral plexus innervates the legs. Its major branches include:

- Femoral nerve—The femoral nerve innervates the muscles in the front of the thigh, including the quadriceps group. It also gives off cutaneous branches to the skin of the anterior and medial distal thigh and the medial leg and foot.
- Obturator nerve—The obturator nerve innervates muscles of the medial thigh and the skin of the distal medial thigh.
- Sciatic nerve—The sciatic nerve is the largest nerve in the body and is found in the posterior thigh. It innervates the muscles of the calf and the back of the thigh and the skin of the lower calf and the upper surface of the foot.
- Superficial peroneal nerve—The superficial peroneal nerve innervates the lateral leg muscles and the skin on the back (dorsum) of the foot.
- Deep peroneal nerve—The deep peroneal nerve innervates the anterior and lateral leg muscles and the muscles that move the toes.
- Tibial nerve—The tibial nerve innervates the skin and muscles of the posterior leg and the sole of the foot. Damage to the tibial nerve results in "footdrop," the inability to dorsiflex the foot, that is, to bend it backward by flexing the ankle.

## Autonomic Nervous System

The autonomic nervous system stimulates the smooth muscle of the blood vessels and the bowel, the heart muscle, and some endocrine glands. This system maintains the various bodily functions over which the individual has no conscious control, including blood pressure, temperature regulation, sweating, and peristaltic activity of the bowel. In stressful situations, the autonomic nervous system also helps the body produce the appropriate "fight or flight" response, characterized by changes in blood flow and metabolism.

The autonomic nervous system is divided into the parasympathetic nervous system, which controls the involuntary functions mentioned above, and the sympathetic nervous system, which prepares the body for stress. The parasympathetic nerves release acetylcholine when stimulated. This chemical transmitter crosses the synapse (neuromuscular junction) to stimulate the end organ, or muscle. Effects of acetylcholine (cholinergic effects) include salivation, pupillary constriction, slowing of the heart, constriction of bronchial smooth muscle, and increased intestinal motility.

Because atropine inhibits the breakdown of acetylcholine at the neuromuscular junction, increasing cholinergic activity, it is used clinically to increase the heart rate. Some insecticides, notably those of the organophosphate type, block cholinergic activity and can lead to fatal paralysis and cardiac arrest unless their effects are countered by treatment with atropine.

The sympathetic nervous system has more widespread effects than the parasympathetic system. Chemical transmitters in the sympathetic nervous system include norepinephrine, which is released from sympathetic nerve endings, and epinephrine (Adrenalin), which is released from the adrenal gland when it is stimulated by the sympathetic nerves. Sympathetic nervous stimulation increases the heart rate (pulse) and the force of cardiac contraction. In the blood vessels, sympathetic stimulation of specialized receptors (called beta-1 and beta-2 adrenergic receptors) can both increase and decrease the muscular tone of the vessel wall and influences blood pressure and blood flow to different parts of the body.

Damage to the thoracic and lumbar segments of the spinal cord can cause derangement of the sympathetic nervous system, which originates in those areas. Such damage can lead to heat loss and shock; as vascular tone diminishes, blood collects in the extremities.

## Protective Mechanisms for the Central Nervous System

The brain and the spinal cord do not have the ability to regenerate if cells are permanently damaged. Although some brain cells can take over the functions of other, damaged cells, the amount of function regained cannot be predicted and is usually limited. To prevent additional damage, any patient with possible neurological injury must be handled very carefully in the emergency treatment situation.

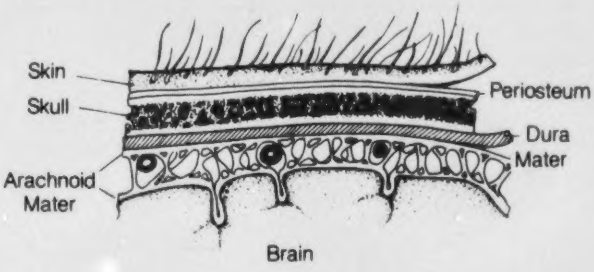

**Figure 11. Protective Mechanisms for the CNS**

Fortunately, there are several protective mechanisms for the structures of the CNS (see Fig. 7.11). The skull provides a rigid container for the brain, and the spine protects the spinal cord. Within these bony structures, three layers of tissue, called meninges, provide additional protection.

The first of these layers is the dura mater, the thick fibrous outer covering of the brain. It is attached to the skull except at the falx cerebri, which separates the two halves of the cerebrum, and the tentorium cerebelli, which separates the occipital lobe of the cerebrum from the cerebellum. These dural infoldings provide a suspension system for the brain and help prevent excessive motion within the skull. The dura mater also forms the outer covering of the spinal cord.

The second layer of tissue is called the arachnoid membrane. Between the arachnoid membrane and the dura mater is the subdural space in which blood vessels and nerves pass to and from the brain.

The third layer is the pia mater, which is closely attached to the surface of the brain and spinal cord and dips into every fold of their surfaces. Between the arachnoid membrane and the pia mater is the subarachnoid space, which is filled with cerebrospinal fluid (CSF).

The CSF protects the brain and spinal cord by providing a cushion between them and their adjacent bony structures. Clear and colorless, the CSF circulates through and around the brain and spinal cord before being resorbed. When tears in the dura mater occur, usually after skull fractures, the CSF may leak out through the nose or the ears. Leakage of CSF indicates a critical situation, as it signals serious injury to the CNS and possible infection (meningitis).

## Unit 2. Patient Assessment

It is often difficult to assess patients with CNS problems. Because their mental functioning is often impaired, they may be unable to give coherent histories or to cooperate in physical examinations. In such cases, you must obtain information from careful observation. All injuries and illnesses that interfere with brain and spinal cord functions are serious. Since improper management of these conditions can, in many cases, cause permanent disability or death, careful assessment is particularly important.

### History

If you cannot obtain a history from the patient, you can question bystanders or family members and observe the patient's environment. If the patient is a trauma victim, answers to the following questions are particularly important:

- When did the accident occur?
- How did it occur? What were the mechanisms of injury? Did the patient sustain a direct blow to a specific part of the head or spine? Was the spine flexed, extended, or twisted? Was there a rapid deceleration?
- Was the patient unconscious at any time? For how long?
- If the patient is able to communicate, what is the chief complaint? Does the patient experience any pain, numbness, tingling, or paralysis? Have the symptoms changed since the accident?
- Are there possible complicating factors such as significant underlying medical problems or recent ingestion of drugs or alcohol?
- Has the patient moved or been moved since the accident?

The history of the patient with nontraumatic CNS problems also is important. If you can obtain a sufficient history, you should be able to identify the patient's problem more than 80 percent of the time. You should try to determine:

- The chief complaint and the details of the present illness, if the patient can communicate
- Whether the patient has any underlying medical problems
  —Does the patient have heart trouble (cardiac arrhythmias), which may lead to fainting (syncopal) episodes?
  —Is the patient a chronic seizure patient who has not taken prescribed medications?
  —Is the patient a diabetic who took too much or too little insulin?
  —Does the patient have hypertension?
  —Has the patient ever had symptoms like these before?
- Whether there are any environmental clues that could provide important information if the patient cannot communicate
  —Are there any medicine bottles in the patient's pockets, in a purse, or around the home?
  —Does the patient wear a Medic Alert tag or carry a card indicating epilepsy or diabetes?
  —Are there any alcohol bottles or drug paraphernalia in the vicinity?

### Physical Examination

The physical examination begins with the primary survey. You should check the patient's pulse and screen him or her for any life-threatening problems. Such problems should be identified and treated before the patient is given a detailed neurological examination. If the patient is unconscious, pay special attention to maintaining an open airway. Because all trauma victims must be assumed to have cervical spine injuries until proven otherwise, you should not hyperextend the patient's neck to open the airway. The "chin lift" or the "modified jaw thrust" as shown in Figure 7.12 usually allows placement of an oro-

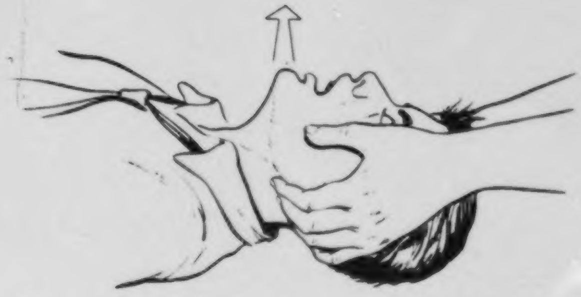

Figure 12. Chin Lift Method of Opening an Airway

pharyngeal or nasopharyngeal airway in the unconscious patient.

Patients with major head trauma and serious neurological injury frequently stop breathing. Increased intracranial pressure, caused by bleeding within the skull, can exert pressure on vital control centers and can decrease the patient's ability to breathe, as can direct injury to the medullary breathing centers. If there are facial injuries, blood can flow into the airway and be aspirated into the lungs. If an unconscious patient vomits, stomach contents, including swallowed blood, can also be aspirated. These patients lack the protection usually given by the gag reflex. In many patients, the tongue may flop back and obstruct the back of the throat. The chin lift or jaw thrust easily removes this type of obstruction.

After an airway is assured, check the vital signs carefully. Patients with neurological injury may have changing vital signs. The pattern of these changes can aid in making management decisions, so the vital signs should be rechecked and recorded frequently.

The pattern of respiration and the respiratory rate may vary with the nature and extent of the brain injury. The breathing pattern may be normal, or the patient may exhibit Cheyne-Stokes respiration. In this situation, respirations increase in rate and depth until the patient is hyperventilating and then decrease until the patient appears to stop breathing (apnea). The patient may also exhibit central neurogenic hyperventilation, which is a sustained pattern of deep and rapid breathing. Following central neurogenic hyperventilation, the patient may exhibit ataxic respiration, in which breathing becomes irregular and ineffective. Following a period of ataxic respiration, the patient may eventually stop breathing. Since many patients with serious neurological injury follow this sequence of breathing patterns, serial observations are important for good patient management.

Cervical spinal cord injuries also can impair respiration. "High" cervical cord damage (at C3) can produce complete respiratory muscle paralysis. Damage at the C5-to-C6 level will paralyze the diaphragm, but intercostal muscles (those between the ribs) will continue to function. Remember that neck injuries must be treated very carefully to prevent further damage.

Characteristic changes in blood pressure also occur as intracranial pressure rises. During the early stages, of increasing intracranial pressure, the pulse slows and the blood pressure and temperature rise. Later, as the pulse rate increases, the blood pressure falls to normal or below-normal (hypotensive) levels while the temperature remains elevated. As these changes develop over time, it is especially important to make serial observations of the patient's vital signs. If the patient has low blood pressure and a rapid pulse initially, he or she may be suffering from hemorrhagic, cardiogenic, or neurogenic shock. You should look for other injuries—for example, a fractured femur or a ruptured abdominal organ—before explaining changes in vital signs on the basis of neurological injury alone.

After checking and recording the vital signs, you should conduct a head-to-toe survey, paying particular attention to skull injuries, which may be closed or open. A scalp laceration may bleed profusely. On the other hand, a patient with a skull fracture may not have obvious signs of such an injury on initial inspection. Therefore, you should palpate the skull carefully, looking for asymmetry or depression of the skull bones. Blood coming from the ears may also indicate a skull fracture. Blood coming from the nose most often flows from a nasal injury, but it, too, can stem from a skull fracture. Clear fluid coming from the ears or nose may be CSF, indicating a major skull fracture. Purple discoloration (ecchymosis) around the eyes (raccoon sign) also suggests a basilar skull fracture.

Following the head-to-toe survey, you should assess the patient's higher neurological function by checking his or her state of consciousness. Descriptive words like "stupor" or "semi-coma" should be avoided when assessing the patient's condition, because each paramedic, nurse, or doctor will interpret these words differently. Behavioral terms should be used instead; that is, you should describe what the patient can and cannot do. To assess whether the patient is alert and oriented to person, place, time, and situation, ask the patient for his or her name; the day of the week, date, and year; where he or she is; and where he or she lives. You can also ask the patient what is happening and why the ambulance was called. In addition to assessing the level of consciousness, this questioning aids in gathering information about the patient. Also note the patient's rate of speech. Is the patient's speech rambling, garbled, or absent? Does the patient respond appropriately to questions? Does the patient respond rapidly or sluggishly to commands? Does the patient make purposeful or uncoordinated movements?

If the patient is not alert, does he or she awaken when his or her name is called, when shaken, or when painful stimuli are applied to varying degrees?

The standard painful stimulus is a knuckle pressed forcefully into the patient's sternum with varying de-

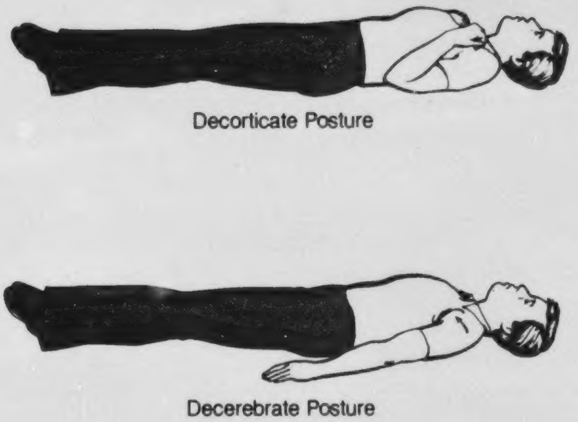

**Figure 13. Decerebrate vs. Decorative Posturing**

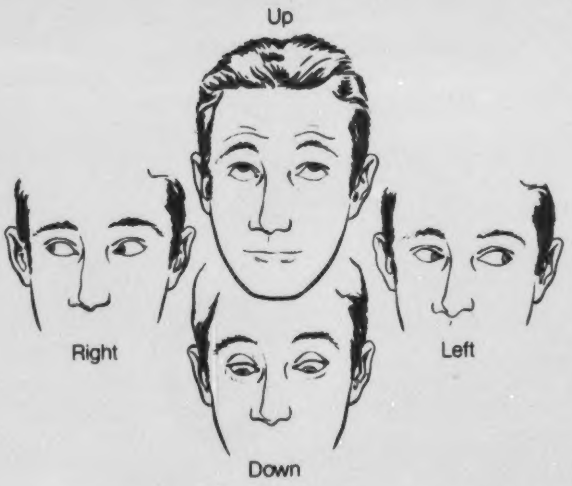

**Figure 15. Technique for Examining a Patient's Eye Movement**

grees of pressure or a pin stuck into the skin of the arm or leg. The patient's reaction to painful stimuli is an important indicator of mental functioning. If the patient attempts to push your arm away, movements are purposeful. If there is major neurological injury, the patient may respond to painful stimuli with stereotyped postures. In decerebrate posturing, both arms and legs are extended; in decorticate posturing, the arms are flexed but the legs remain extended (see Fig. 7.14).

Next, check the patient's pupils. Are the pupils the same size? (Some people normally have slightly unequal pupils, so this sign is less significant if the patient is conscious.) Are the pupils abnormally dilated or constricted? Heroin causes very small pupils; many other drugs cause large pupils. Do the pupils react quickly to light directly (when the light is shined into the eye being tested) and consensually (when the light is shined into the other eye)? In cases of increased intracranial pressure, compression of the nerve which controls pupil constriction leads to dilation of the pupil—a "blown pupil" (see Fig. 7.15). If the patient is wearing contact lenses, you should remove them when you check the pupils.

The extraocular movements are also important. Inability to move the eyes appropriately indicates damage to the nerves leading to the eyes or to the brain stem nuclei controlling these nerves. If the patient is conscious, ask him or her to follow your fingers or a light to the extreme left, then up and down, then to the extreme right, and up and down. The eyes should move fully, in a coordinated fashion. Minor abnormalities of eye motion may be missed unless the patient is asked to look all the way to the left, to the right, and up and down (see Fig. 7.16).

If the patient is unconscious, you can check the integrity of these neurological pathways by performing the "doll's eye" maneuver. If the possibility of cervical spine injury has been ruled out, rotate the patient's head quickly from side to side while the eyes are held open (see Fig. 7.17). The eyes should lag behind the motion of the head, as in some toy dolls; if the eyes move with the head, serious brain damage is present. A checklist has been developed by the American College of Surgeons* to help paramedics and physicians record this information accurately. The rescue vehicle should be equipped with a supply of these forms, to be used in the assessment of patients with neurological damage.

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*For a copy, write to the attention of the Trauma Department, American College of Surgeons, 55 East Erie Ave., Chicago, IL 60611.

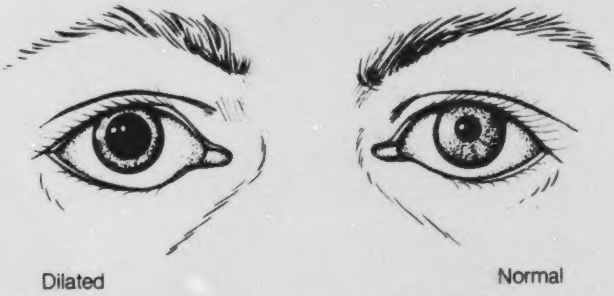


**Figure 14. Dilated Pupil**

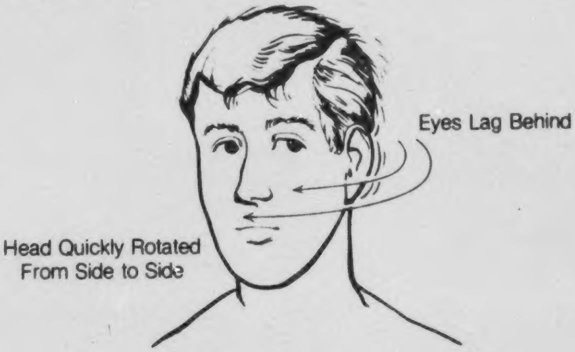

Eyes Lag Behind
Head Quickly Rotated From Side to Side

**Figure 16. Procedure for Checking for "Doll's Eyes"**

After examining the head and assessing the higher mental functions, check the patient for spinal injury. If there is any question of serious spinal damage, immobilize the patient first and do the assessment later. If the patient's back can be seen, you should look for cuts and bruises near or over the spine and note any obvious deformity of the spine. Run your fingers down the spine, feeling for any bony protrusions and noting any painful areas. Finally, check the patient for any visible paralysis of the extremities. If bony deformity or obvious paralysis is present, the patient should be immobilized before the assessment is continued as appropriate.

Because loss of function occurs below the injured segment of the spinal cord, the survey should be started at the lowest point of the lower extremities, the feet. Motion, sensation, and position sense (proprioception) should be checked. If the patient can communicate, ask if he or she can feel the feet and legs being touched. Also ask if he or she can wiggle the toes or raise the legs. You can move the patient's toes up and down without the patient seeing and ask the patient to tell in which direction the toes are being moved. To avoid giving the patient misleading clues, hold the toes on either side rather than on the top and bottom (see Fig. 7.18). If the patient can perform these simple tests without difficulty, the integrity of the posterior column, lateral spinal thalmic tract, and cortical spinal tract has been demonstrated, and there is no indication of damage to the spinal cord. If the patient can perform these tests only to a limited degree and with pain, there may be pressure on, or damage to, the cord. The patient should be immobilized in this case. Inability to perform any of these tests is a strong indication of severe damage to the spinal cord. Immobilize the patient to prevent any further damage to the cord.

Check the function of the upper extremities (arms) to see whether there is damage to the spinal cord in the neck (cervical spine). Follow the same basic procedures used to assess the function of the lower extremities. Touch the patient's hands and arms and ask whether the touch can be felt. Move the patient's finger up and down to determine if he or she knows in which direction it is being moved. Ask the patient to squeeze your fingers tightly. The average adult should be able to squeeze tightly enough so that it will be difficult for you to remove your fingers. If the patient can perform all of these tests, there is no indication of cervical cord damage. If a cooperative patient is unable to perform any of these tests, the neck is damaged and should be immobilized. You should attempt to confirm the level of the injury by performing a dermatome survey; that is, check where the patient loses sensation. Remember that patients who cannot talk may be able to respond to commands.

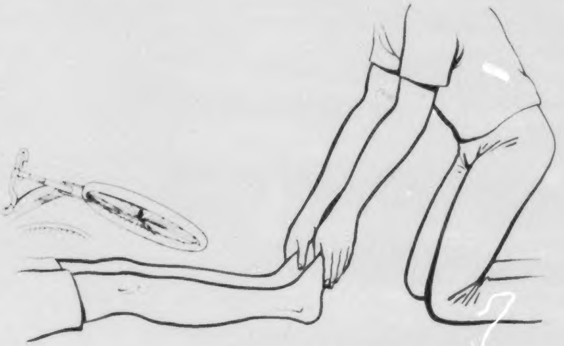


**Figure 17. Procedure for Performing a Neurological Examination by Holding a Patient's Toes**

If the patient is unable to respond to commands—as a result of loss of consciousness, for example—you can assess neurological damage by jabbing him or her lightly on the sole of the foot or on the ankle with a sharp object. If the spinal cord is intact, reflexes will cause the foot to pull back in response. If there is no response, there may be paralysis or the patient may be deeply comatose. Repeat this test on both feet and both hands.

When checking for paralysis, you should test all extremities, both right and left. Paralysis in both legs (paraplegia) or in both arms and both legs (quadriplegia) indicates spinal cord damage. Paralysis of the arm and leg on one side of the body (hemiplegia) may indicate a stroke or cerebrovascular accident (CVA). The most reliable sign of spinal cord damage is paralysis, but this sign may not be present despite cord damage. Spinal cord damage can coexist with spinal deformities and pain, tenderness, cuts, or bruises in the spinal area. If there is any question of spinal cord damage, immobilize the patient. While performing the complete neurological assessment, continue to monitor vital signs, level of consciousness, and pupillary reflexes. Watch patients carefully for the development of shock.

In summary, assessment of the patient with possible neurological injury involves appropriate history and physical examination. You must determine whether there is trauma. You should find answers to the following questions: What happened? How long ago? Are there any complicating factors? Is there any pain, numbness, or loss of motion or sensation? Check the patient's head to determine if there are skull injuries and to assess the level of consciousness and the presence or absence of pupillary signs. Next, check the spine for deformity, pain, or tenderness. Then you should test the patient for signs of paralysis, first checking the legs and the arms. Frequently assess vital signs, the state of consciousness, and the state of the pupils; you should be alert to changes that indicate a deterioration of the patient's condition.

# Unit 3. Pathophysiology and Management

## Pathophysiology of Head Trauma

Head trauma can injure the scalp, the skull, or the brain. The scalp bleeds easily when injured, but the brain usually is not injured in superficial scalp lacerations. If the skull is fractured, however, at least minimal brain injury must be suspected. The brain can be injured either directly or indirectly, and it may be injured without apparent scalp or skull damage.

The protective mechanisms of the brain have already been discussed. When the brain is forced to move rapidly within the skull (e.g., when a victim is hit on the head), the areas in the brain stem that control consciousness may be damaged, causing the victim to lose consciousness. This syndrome is called concussion. If the injury is minor, the patient will regain consciousness rapidly. The longer the period of unconsciousness, the more severe the damage to the brain. A more severe injury produces tissue damage in the brain stem and is called brain stem contusion. The surface of the cerebral hemispheres (cerebral cortex) may be damaged directly if it strikes the inner surface of the skull, producing cerebral contusion. Such an injury may produce memory loss, confusion, or other signs, but it usually does not produce unconsciousness by itself. Patients with direct brain injury—brain stem concussion, brain stem contusion, and cerebral contusion—usually remain stable or improve over time.

In contrast, patients with indirect brain injury caused by blood accumulating within the skull usually deteriorate over time. Accumulation of blood within the skull results in increased intracranial pressure and compresses vital structures of the brain and brain stem. An epidural hematoma (see Fig. 7.19) occurs when blood vessels located between the skull and the dura mater are torn by a skull fracture. Blood can collect rapidly. With such an injury, the patient often loses consciousness from a brain stem concussion, then regains consciousness, but begins to deteriorate as blood collects in the skull, resulting in increased intracranial pressure. In a subdural hematoma, bleeding is from torn vessels between the dura mater and the arachnoid mater. The subdural hematoma usually develops more slowly than the epidural hematoma, and deterioration is more gradual. When the blood clot is large enough, intracranial pressure increases, and respiratory and other centers are compressed.

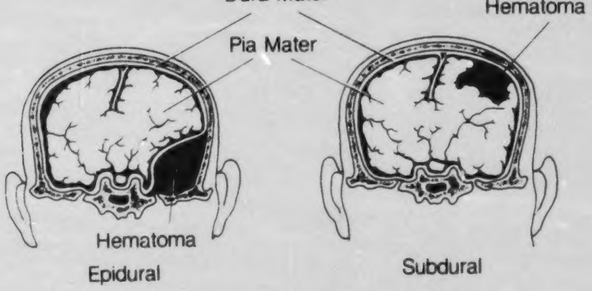


**Figure 18. Epidural Hematoma**

Often the nerve controlling the pupillary constrictor muscle is compressed causing the pupil to dilate widely; this indicates severe brain damage. Eventually, the cardiorespiratory centers may stop functioning, and the patient with indirect brain injury may stop breathing. Because such a patient deteriorates over time as the collection of blood inside the skull increases, serial observations must be made in assessing neurological injury. Neurosurgical intervention to drain the intracranial hematoma can be life-saving in such cases.

In extremely severe head injuries, the skull may be fractured and pieces of bone driven into the brain matter. Cortical cells are destroyed. If the patient survives, the degree of loss of neurological functions will depend on the quantity and location of the cortical cells lost or damaged. If the skull is fractured in such a way that the brain is exposed, significant damage to brain tissue usually will occur very quickly. These patients are susceptible to serious infections of the brain (cerebritis) and meninges (meningitis).

Head trauma is commonly sustained as a result of auto accidents, falls, and direct blows to the head. The most important part of the assessment is determining whether the patient's neurological function is changing and, if so, how. Repeated neurological examinations must be performed, both in the field and in transit, and an accurate record of these examinations must be kept. Patients who show signs of improvement may simply need to be observed in the hospital, but those patients who deteriorate rapidly may require urgent neurosurgical intervention.

An accurate history can be of great value in determining the potential seriousness of the injury. You should obtain the following information from the patient with head trauma:

- What was the mechanism of injury?
- Did the patient lose consciousness? When? How long was the patient unconscious? Did unconsciousness occur immediately after the accident, or later?
- Did the patient vomit? Children frequently vomit after head injury, but vomiting in adults may indicate serious intracranial problems.
- What symptoms does the patient have now? Headache? Dizziness? Double or blurred vision? Nausea? Weakness? Can the patient move all extremities? Does the patient have any pain in the head, neck, or spine? Does the patient have numbness or a "pins-and-needles" sensation?

- Has the patient ingested any alcohol or drugs in the past few hours?

The physical examination must be performed after the history is taken, and it should be repeated several times. The primary survey should be conducted first. A patient should not be moved until it has been determined that there is no associated spinal injury. Always assume that a patient with significant head trauma has a cervical spine injury until it is proven otherwise, and handle patients accordingly. Keep the airway clear, and be sure that the patient is breathing adequately. Check the patient's pulse, and halt any active bleeding by direct pressure. Then observe other parts of the body for life-threatening injuries, such as sucking chest wounds or severe lacerations.

Take the vital signs at 5-minute intervals. Note the rate and pattern of the respirations. You should determine whether an abnormal pattern is present or whether the patient is breathing only with his or her diaphragm. You should also note any changes in blood pressure over time.

Blood pressure may rise as intracranial pressure increases. Falling blood pressure is rarely caused by head injury; if it accompanies head injury, you must look for a source of major hemorrhage elsewhere in the body. For example, pelvic or femoral fractures, which are not uncommon in automobile accident victims, are associated with significant hidden blood loss. You should determine whether the pulse increases or decreases. A slow pulse usually accompanies a rise in blood pressure in patients with increasing intracranial pressure. However, a rising pulse also may signal impending shock from bleeding somewhere else in the body.

Examine the head carefully. Are there scalp lacerations or depressions in the skull? Is there blood or clear fluid in the ear canals? Are there bruises (ecchymoses) behind the ears (Battle's sign) or around the eyes (raccoon sign)? Is clear fluid leaking from the nose? If clear fluid, which should be presumed to be CSF, is leaking from the ears or the nose, do not attempt to block the flow; simply cover the ear or the nose with sterile gauze.

The patient's neck should be assessed next. Manual traction should be maintained while you palpate the patient's neck for vertebral irregularities or tenderness. The conscious patient can tell you whether his or her neck hurts. The comatose or confused patient, on the other hand, will not be able to tell you what hurts. When in doubt, you should maintain traction and apply a cervical collar or immobilize the neck by other methods.

The standard physical exam should be completed in the usual head-to-toe order, and you should look for fractures or lacerations. Never move the patient until the whole length of the spinal column has been checked.

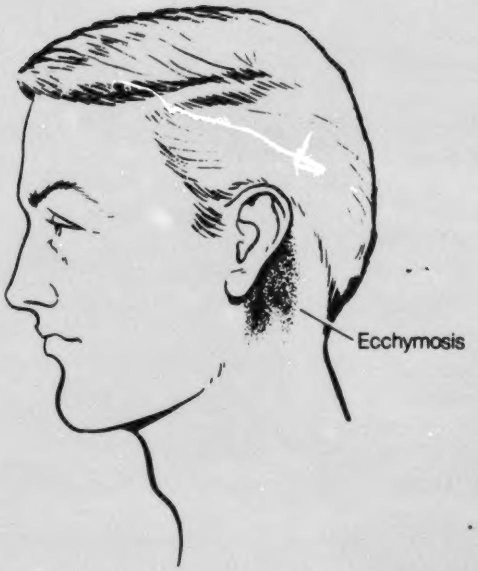


**Figure 19. "Battle's Sign"**

A neurological exam should then be conducted, and the findings should be recorded carefully. Is the patient alert? Is the patient oriented? Is the patient able to understand questions and to obey simple commands? What type of stimuli are required to make the patient respond if he or she is not fully alert? Can he or she make purposeful movements? As was noted earlier, you should describe what the patient can and cannot do in behavioral rather than descriptive terms, as these often have different meanings for different medical personnel. Check the eye movements, and in an unconscious patient look for the "doll's eyes" response. Also assess the pupils' reactions to light.

In the field, there is relatively little specific treatment for the patient with head injury. The cardinal principles are to maintain the patient's current status and to prevent further injury. You can accomplish these ends by taking the following steps:

- Keep the patient in a supine position.
- Establish an airway, being careful not to aggravate possible cervical spine injury, with slight *reverse* Trendelenburg.
- Maintain axial traction on the neck, and apply a cervical collar whenever associated cervical injury is a possibility.
- Administer oxygen, and assist ventilations if necessary.
- Start an intravenous (I.V.) line with 5 percent dextrose in water (D5W) at a keep-open rate. Be careful not to infuse too much fluid, which can increase the swelling of the brain (cerebral edema) that may occur in head injury.
- Monitor cardiac rhythm, which may be altered if the brain stem is damaged.

- Alert the receiving facility of the patient's condition and estimated time of arrival so that a neurosurgical team can be notified if necessary.
- Transport the patient smoothly. Remember to continue taking vital signs and to check the neurological status en route, recording the results of each examination.

## Spinal Injury

Like the brain, the spinal cord can be damaged by direct injury. The spine, however, has less protection than the brain because its bony protection is flexible. The thoracic vertebrae are splinted by the ribs and associated muscles, so injury to the thoracic spine is relatively rare. The neck, however, lacks this support and is the most flexible part of the spine, so injuries to the cervical cord are quite common. The size and muscular protection of the lumbar spine make it somewhat more resistant to injury than the cervical spine, but it is still less resistant than the thoracic spine.

The cord may be injured by compression from flexion or twisting, laceration or compression from bony fragments of the spine in spinal fractures, protrusion of the cartilage disks between vertebrae into the spinal canal, dislocation of one vertebra from the vertebra below it, or bleeding into the spinal canal, which can result in a spinal epidural hematoma or compression of the cord (see Fig. 7.20). To avoid further damage to the cord, all suspected injuries should be treated as actual spinal cord injuries.

When the spinal cord is lacerated or compressed, nerve fibers that carry impulses to and from the brain are disrupted. There is a direct relationship between the location of a spinal cord injury and any loss of function in the extremities. This relationship is based on the distribution of nerves that branch off the spinal cord at each segmented level. When a specific pathway is interrupted, the function of the extremity served by that nerve is affected. In other words, when the pathway is broken, the message cannot be carried.

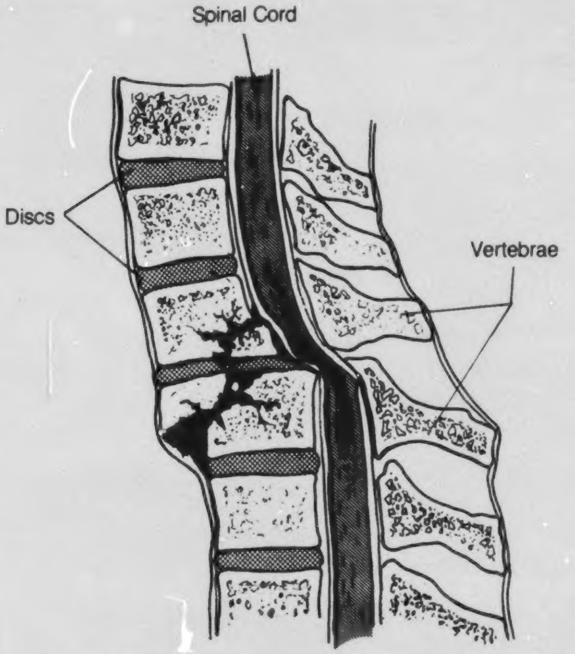


**Figure 20. Spinal Cord Compression from Twisting or Flexion**

The initial care of the patient with spinal injury can determine whether he or she regains normal function or is permanently crippled. In few other areas of emergency care will your care be so critical to the patient's long-term future. To avoid further injury to the patient, you must be knowledgeable and skilled in the management of spinal trauma. Again, the history can provide important clues to the nature of the injury and to its subsequent management. Spinal injury should be suspected in patients injured in automobile, sledding, or diving accidents, and in falls. You should try to determine the precise circumstances of the accident. Was the neck flexed, extended, or twisted? When did the accident occur? (If more than 6 hours have elapsed since the accident, the chance of restoring any lost function is greatly diminished.) Does the patient have localized pain in the neck or back? Is there numbness or tingling in any extremity? Are the extremities weak? If the patient is unable to move, you should find out if the patient was able to move at any time after the accident. Because a patient who has any movement at all after spinal injury has a better chance of recovering nerve function, it is important for the physician to know this. Has the patient been moved since the accident? Have symptoms changed since the injury?

The physical examination of the patient with possible spinal injury is similar to that for patients with head injury. During the primary survey, initial examination, and examination for vital signs, the patient should be moved as little as possible. The patient should be logrolled while you maintain axial traction on the head to permit inspection of the back for swelling or hematoma of the spine. This symptom usually indicates vertebral fracture. Any deformities or local tenderness in this area should also be palpated. Any paravertebral muscle spasm encountered during the examination is a protective mechanism and can also indicate an injured area of the spine. Any open injuries of the spinal column should be covered immediately with sterile dressings. You should perform a dermatome survey with a pin or other sharp object to check for any loss of sensation or motion. You should be familiar with the innervation points of various spinal nerves. Thus, if sensation is present at the nipples (T4) but absent at the umbilicus (T10), you know the injury is probably between the 5th and 10th thoracic vertebrae. You should check position sense, pain sensation, and movement in the extremities, determining the answers to the following questions: Can the pa-

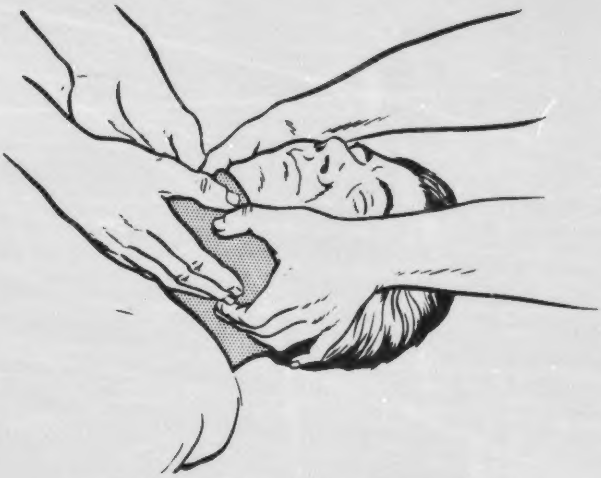


**Figure 21.** **How Axial Traction Is Maintained While Cervical Collar Is Applied**

tient move all extremities? Is strength equal bilaterally? Is the patient unable to perform any specific movements? Spinal injury can damage the sympathetic nervous system and cause blood pressure to fall precipitously. Since the patient may be unable to conserve body heat, he or she should not be left uncovered for prolonged periods.

As with head injury, management is aimed at supporting vital functions and preventing further spinal cord damage. To manage spinal injuries, you should:

- Establish and maintain an airway, being careful not to worsen possible cervical spine injury.
- Administer oxygen and assist ventilation as needed.
- Maintain axial traction and immobilize the neck with a cervical collar (see Fig. 7.21). Sandbags can help limit neck motion.
- Immobilize the patient on a long spine board whenever a spinal injury may have occurred. When in doubt, immobilize. Patients will not be harmed by unnecessary spinal immobilization, but they can be seriously injured if they do have spinal injuries and are not immobilized.
- Start an I.V. with D5W. Treat shock if it is present.
- Keep the patient covered to avoid heat loss.
- Notify the receiving facility of the patient's condition and the estimated time of arrival. Patients with spinal injury should be transported to a fully staffed and equipped spinal cord trauma center if possible. Be familiar with the facilities in the community.

Remember that damage to the spine does not produce neurological defects unless damage to the spinal cord has also occurred. Every spine injury, especially above the clavicles, should be treated as if a fracture exists. In treating spinal injury, never underestimate the possible damage or its consequences.

## Coma

Coma may be defined as an abnormally deep state of unconsciousness from which the patient cannot be aroused by external stimuli. Coma can be caused by illness or injury. A normal level of consciousness requires continuous interaction between the cerebral hemispheres and various structures in the brain stem. Varying degrees of unconsciousness can occur because of compression or destruction of either of these two components. Factors causing coma include direct damage to the brain stem, as in a concussion; an expanding lesion within the skull, such as an intracranial hematoma, which causes pressure on the brain stem; or metabolic states that depress neurologic function widely. Very often it will be difficult to determine the cause of coma and to treat it in the field. Thus your role will be to maintain the patient until he or she can be transferred to a medical care facility.

Since the comatose patient obviously cannot give a history, you must rely on bystanders, family members, and observations of the environment. You should seek answers to the following questions: How long has the patient been comatose? Did this state begin suddenly, or did the patient lapse into coma gradually? Did the patient suffer a blow to the head recently, or in the last few weeks? Is the patient under a doctor's care for any conditions? Is the patient known to abuse drugs or alcohol? Did the patient complain of any symptoms before becoming comatose?

You should check bureau tops, medicine cabinets, kitchen counters, refrigerators, and the patient's pockets for medications that might give a clue to any underlying illness. You also should look for evidence that the patient may be diabetic or epileptic by checking for a Medic Alert bracelet or necklace or a card in the wallet or purse. Also check the area in which the patient is found for indications of alcohol or drug abuse, such as liquor bottles or drug paraphernalia. Remember the common causes of coma, which are described below, and try to obtain information that will help narrow the possibilities.

- Trauma may not be apparent from a cursory examination of the patient. A complete neurological examination should be performed on the comatose patient.
- The patient may be in a coma from either hypoglycemia (low blood sugar) or insulin reaction (ketoacidosis). To determine whether the patient is diabetic, seek answers to the following questions:

—Does the patient wear a Medic Alert bracelet?
—Is the patient carrying any medication? (Diabinese and Orinase are two medicines frequently taken by adult diabetics.)

—Are there insulin syringes in the house, or is there insulin in the refrigerator?
—Does the patient's breath have a fruity odor?

- There are rarer causes of coma than diabetes, and it is important for paramedics to know them. Again, look for the Medic Alert tag, as it can indicate thyroid, adrenal, renal, or other problems. Check the surroundings for any medications that indicate other serious medical problems.
- Drug overdose is a common cause of coma. Attempt to find answers to the following questions:
  —Are there needle tracks on the arms?
  —Are the pupils pinpoint in size (suggesting heroin overdose) or widely dilated (suggesting barbiturate overdose)?
  —Is the patient carrying any sedative drugs?
  —Did the patient leave any notes nearby?
  —Are the respirations very slow and deep?
- Paramedics should ask the following questions when stroke or other hypertensive emergencies are suspected:
  —What is the blood pressure?
  —Are the pupils equal and reactive?
  —Is one side of the body paralyzed?
  —Is the patient carrying any antihypertensive medication?
- To determine the possibility of meningitis, the following questions should be answered:
  —Did the patient have severe headaches before the coma began?
  —Did the patient have a fever or behave in a confused manner?
  —Does the patient have a rash?
  —Is the neck rigid?
- In cases of seizures, you should seek answers to the following questions:
  —Does the patient have a history of seizures?
  —Were there witnesses to the patient's seizure?
  —Is the patient carrying medicines for seizures? Three common medications are Dilantin, phenobarbital, and Mysoline.
- To determine the possibility of alcoholic coma, the following questions should be answered:
  —Is there a smell of alcohol on the patient's breath?
  —Are there alcohol containers lying around?

A patient who has alcohol on the breath, or who is a known alcoholic, may be comatose from other causes. Check the patient carefully.

With the exception of trauma and stroke, the common causes of coma can be remembered by the mnemonic AEIOU: Acidosis—diabetes and other types of acidoses; Epilepsy; Infection—meningitis; Overdose—alcohol and drugs; Uremia—kidney failure and other metabolic disorders.

Because the patient cannot tell you what hurts and because little or no history may be obtainable, the physical examination must be especially thorough. A complete neurological evaluation should be performed as outlined in earlier parts of this chapter.

The cardinal principle of the management of comatose patients is to remember that they have lost the ability to protect themselves and are entirely dependent on their rescuers. To manage the comatose patient effectively, you should:

- Establish and maintain an airway. The comatose patient has often lost reflexes that prevent aspiration. Insert an oropharyngeal airway and see whether the patient gags. If this happens, the patient has sufficient reflex activity left and intubation is not necessary. If not, the patient is in danger of aspirating and should be intubated if there is any question of the airway status.
- Support ventilation as necessary. Administer low-flow oxygen.
- Start an I.V. with D5W to keep the vein open, simultaneously drawing blood for laboratory studies.
- Obtain orders to administer 25 grams (g) of glucose I.V.
- If the pupils are pinpoint, if needle tracks are present on the patient's arms, or if there are other suggestions of drug abuse, consult the physician about administering the narcotic antagonist naloxone (Narcan). Administer Narcan with a slow I.V. and observe the patient for an improvement in respiration or level of consciousness. Narcan is short-acting and may have to be given repeatedly.
- Monitor the patient by telemetry or a portable unit.
- Transport the patient to the hospital in a supine position while watching respiration.

## Seizure

Seizures result from the massive electrical discharge of one or more groups of neurons in the brain. A variety of medical conditions increase the instability or irritability of the brain and can lead to seizures; these include stroke, head trauma (recent or past), withdrawal from drugs or alcohol, inadequate oxygen (hypoxia), low blood sugar (hypoglycemia), and meningitis. Most patients with seizures have idiopathic epilepsy; that is, the cause of the seizures is not known.

There are four main types of seizures:

- Generalized motor seizures (grand mal seizures), which are characterized by loss of consciousness, tonic clonic movements (characterized by phases of continuous muscle contraction as well as phases of alternating muscle contraction and relaxation), and sometimes tongue biting, incontinence, and mental confusion. The grand mal seizure is often frightening to witness and is the type of seizure for which emergency assistance will most often be summoned. The seizure is usually followed by a period of coma or drowsiness, the postictal state (from the Latin "ictus," meaning "seizure").

- Focal motor seizures, which usually cause one part of the body (e.g., one side of the face or an arm) to twitch. Focal seizures can progress to generalized seizures. If the seizure is witnessed, note where the twitching started and in which direction the eyes deviated; this information may help the physician to localize the irritable focus in the brain.
- Psychomotor seizures (temporal lobe seizures), which are characterized by an altered personality state and are often preceded by dizziness or a peculiar metallic taste in the mouth. In some patients, temporal lobe seizures may cause sudden, unexplained attacks of rage; in others, these seizures are manifested by automatic (involuntary) types of behavior.
- Petit mal seizures, which usually occur in children and are rarely an emergency. They are characterized by a brief loss of consciousness without loss of motor tone. The child suddenly stares off into space for a few seconds and then returns immediately to consciousness without showing any motor symptoms.

These four types of seizures, which are caused by temporary cerebral dysfunction, must be distinguished from hysterical seizures, which stem from psychological disorders. Hysterical seizures almost invariably occur in front of an audience. The movements are bizarre and often can be interrupted by a sharp command; the patients rarely injure themselves, bite their tongues, or are incontinent. With experience, you will usually be able to distinguish the hysterical from the genuine seizure.

Because of the nature of the electrical discharge in the brain, seizures usually follow a typical sequence. Many patients experience an aura, a peculiar sensation lasting a few seconds, which precedes and warns of an impending epileptic attack. The aura may consist of auditory or visual hallucinations, a peculiar taste in the mouth, or a painful sensation in the abdomen. The patient then loses consciousness and enters the tonic phase of continuous motor tension, followed by a hypertonic phase with extreme muscular rigidity and hyperextension of the back. During the clonic phase, rigidity alternates with relaxation, and the patient may be incontinent. There is a massive autonomic discharge, accompanied by hyperventilation, salivation, and rapid heart beat (tachycardia). Finally, the patient falls into a postictal stupor, from which he or she awakes confused and with a headache. Knowledge of this sequence can help you distinguish the grand mal from the hysterical seizure.

The following points are important when obtaining the history from the seizure patient, the family, or bystanders:

- Does the patient have a history of seizures? How frequently do they usually occur? Does the patient take medication for seizures? Has the patient been taking medicines according to the doctor's instructions?
- What did the seizure look like? How long did the seizure last? It may be necessary to obtain this information from bystanders if you do not witness the seizure. Was the seizure preceded by an aura? Did it begin in one area of the body and progress to others? In which direction did the patient's eyes deviate? Did the patient bite his or her tongue or become incontinent?
- Does the patient have a recent or remote history of head trauma? Trauma can create irritable foci in the brain that can cause seizures.
- Does the patient abuse alcohol or drugs? If so, when was the last time alcohol or drugs were used? Seizures often occur during withdrawal from alcohol and barbiturates.
- Has the patient recently had a fever, a headache, or a stiff neck? These signs could indicate meningitis.
- Is there any history of diabetes (hypoglycemia can cause seizures), heart disease (arrhythmias can cause cerebral hypoxia, which can lead to seizures), or stroke (damage from old strokes can cause irritable foci in the brain)?

The physical examination is essentially the same as that outlined in earlier parts of this chapter. You should also conduct a thorough neurological evaluation as described above, paying particular attention to:

- Signs of head trauma and injury to the tongue or to other parts of the body which might have occurred during the seizure.
- Evidence of alcohol or drug abuse such as alcohol on the breath or needle tracks on the arms.
- Irregularities in heart rhythm. Monitor the patient if irregularities are found.

Treatment of an isolated seizure is aimed at maintaining an airway and preventing injury to the patient. Use the following guidelines in managing seizures:

- Never restrain the patient during the tonic-clonic phase of the seizure. Protect the patient from falling or banging into surrounding objects; clear furniture and other objects away from the patient. If possible, keep the patient on his or her side to reduce the possibility of aspiration.
- The use of a bite block or padded tongue blade is usually unnecessary. If the teeth are not already clenched, however, place a soft, gauze-wrapped tongue depressor between the molars to prevent

tongue biting. Never jam any object into the mouth if the teeth are already clenched, as this can seriously injure the teeth and mouth. If possible, remove dentures, but be careful to avoid getting bitten.

- Maintain an airway, and administer oxygen.
- After the tonic-clonic phase is over, make sure the patient is on his or her side and continue administering oxygen. Suction the patient's mouth if suction equipment is available.
- Keep the patient in a quiet, reassuring atmosphere.
- Place the patient in a lying-down position for transport. Administer oxygen en route.

Status epilepticus is defined as two or more seizures without an intervening period of consciousness. Unlike an isolated seizure, status epilepticus is a major emergency. Repeated uncontrolled seizures may lead to aspiration, brain damage, fracture of the long bones and spine, death of part of the heart muscle (cardiac muscle necrosis), and severe dehydration. In adults, the most common cause of status epilepticus is failure to take prescribed medicines. Treatment is aimed at maintaining the airway, preventing injury, and stopping the seizures. To do this, you should:

- Place the patient on the floor or a bed away from furniture. Never attempt to restrain the patient.
- Clear and maintain the airway. A nasopharyngeal airway may be helpful.
- Administer oxygen and assist ventilation if there are periods of hypoventilation or apnea. Hypoxia due to impaired respiration is a major complication of status epilepticus.
- Start an I.V. with D5W, simultaneously drawing blood for laboratory studies if possible. Secure the I.V. well.
- Obtain an order to administer 25 g of glucose I.V.
- On physician's orders, administer diazepam (Valium) I.V. to control the seizure. This drug must be administered cautiously because it can cause hypotension and apnea. Before administering diazepam, check the blood pressure. Inject 0.5 ml slowly and check the blood pressure. Continue checking the blood pressure after each 0.5 ml is administered. If the blood pressure begins to fall, stop injecting the drug and notify the physician. If 10 milligrams (mg) (2 ml) of diazepam does not stop the seizures, transport the patient immediately to the hospital. Continue to maintain the airway, administer oxygen, and keep the patient from hurting himself or herself while in transit.

## Stroke

Stroke, also called cerebrovascular accident (CVA), is the common term for a sudden vascular catastrophe caused by thrombosis, embolus, or hemorrhage in the brain. (Thrombosis is the formation of a blood clot. An embolus is a mass of undissolved matter which breaks off and travels through the blood or lymphatic vessels.) When a blood clot blocks the artery carrying blood to a specific area of the brain, the functions governed by that area are damaged or lost. The exact symptoms of a stroke will depend on which area is damaged; motor centers, speech centers, and sensory centers in the brain are commonly affected. Thus, symptoms of stroke often include weakness, paralysis, speech disorders, confusion, and, in severe cases, coma.

Predisposing factors for strokes include high blood pressure (hypertension), diabetes, and abnormal blood lipid levels. Most stroke victims are elderly, but young women taking oral contraceptives and young blacks with sickle-cell disease sometimes have strokes because of their increased susceptibility to cerebral embolism. Certain cardiac arrhythmias also can lead to stroke, either by decreasing cerebral blood flow or by dislodging emboli that can end up in the cerebral circulation.

Some patients experience transient ischemic attacks (TIA's) from which they recover completely within 12 hours. The symptoms of TIA's—weakness, paralysis, and speech disorders—are the same as those of strokes, but they are transient, lasting from a few seconds up to 12 hours. Many patients who have TIA's eventually suffer a complete stroke.

If a patient with suspected stroke is able to give a history, ask about any previous neurological symptoms that might have been TIA's. You should determine the answers to these questions:

- Does the patient have a history of hypertension, cardiac disease, diabetes, sickle-cell disease, or previous stroke?
- If the patient is a woman, is she taking oral contraceptives?
- What symptoms did the patient notice first? Have the symptoms progressed?
- Did anything seem to precipitate the symptoms?
- Did the patient experience dizziness or palpitations? These symptoms may point to underlying cardiac disease as a cause of the stroke.
- Is the patient left- or right-handed?

The signs of stroke found during the physical examination may be obvious or subtle. They include the following:

- Hemiparesis (weakness on one side of the body) or hemiplegia (paralysis on one side of the body). Occasionally only an arm or a leg may be affected.

- Speech disturbances that may vary from slurred speech (dysarthria), inability to speak at all (motor aphasia), inability to understand speech (receptive aphasia), to difficulty in naming objects. If the patient is unable to speak, it is important to determine whether he or she can understand you. To test this, give the patient a simple command, such as "Squeeze my hand."
- Headache.
- Confusion.
- Staggering gait or incoordination of fine motor movements.
- Visual disturbances.
- Inappropriate affect, with excessive laughing or crying.
- Coma, in massive stroke.

You should suspect stroke in any older patient who presents sudden confusion. The classic signs of stroke may not be present in every patient.

The neurological examination described earlier should be performed on each patient with suspected stroke. Pay particular attention to the patient's speech, ability to follow commands, and ability to move the limbs.

Management of the patient with stroke is supportive and is aimed at trying to improve the blood flow and oxygenation to the brain. You should:

- Keep the patient flat.
- Establish and maintain an airway.
- Administer low-flow oxygen.
- Monitor on telemetry or a portable unit, looking for cardiac arrhythmias.
- If the patient is comatose or has significant arrhythmias, start an I.V. with D5W.

A stroke can be frightening to an alert patient, especially if the ability to speak and communicate distress is lost. Indicate that you understand that the patient is going through a frightening experience. Explain each step of the evaluation and treatment and try to be as reassuring as possible.

## Unit 4. Techniques of Management

### Spinal Immobilization

The most common cause of spinal injury is trauma suffered during an automobile accident. In such an accident, the goal is to remove the patient from the vehicle without further damaging the spinal cord. This is best accomplished by using both the short and the long spine boards according to the following procedure:

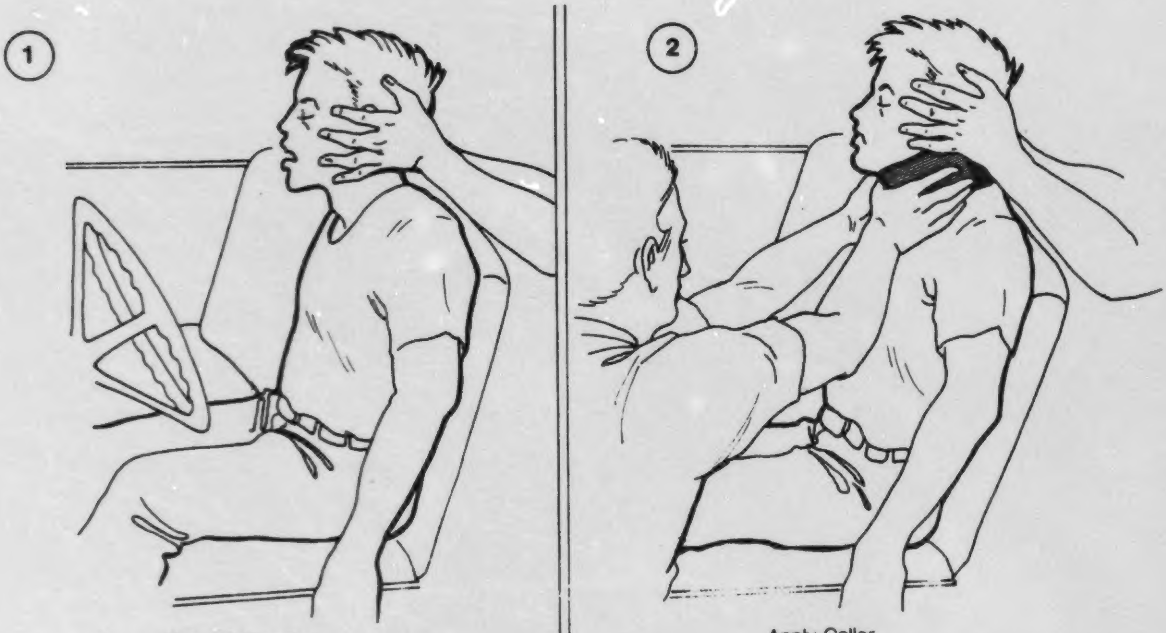
- The first rescuer gets behind the patient, in the back seat if possible (assuming the patient is in front), and maintains axial traction to support the patient's neck in neutral position (see Fig. 7.22).
- The second rescuer can then apply a cervical collar to the patient's neck.
- The second rescuer next prepares a short spine board by placing the straps through the four side slots (not shown in figure).
- While the first rescuer maintains axial traction, the second rescuer slides the short spine board behind the patient so that the patient's head is lined up with the head extension on the board. If the seat is curved, you may need to move the patient slightly forward to get the board behind him or her. Rescuers should coordinate their movements to maintain axial traction.
- When the short board is in position, a folded towel or an airsplint can be used to fill in the gap between the patient's neck and the board. The airsplint has the advantage that its size may be adjusted to fit each patient individually.
- Strap the patient's torso to the spine board using straps with quick-release buckles first. Tape the straps to prevent inadvertent release. The straps should be adjusted so that the buckles are high on the chest near the shoulders; buckles placed over the midchest will get in the way if cardiopulmonary resuscitation becomes necessary.
- The second rescuer then secures the patient's head to the board with a self-adhering (Kling) bandage. Be careful not to cover the patient's mouth or to fasten the straps so tightly that the patient cannot open his or her mouth to cough or vomit.
- After the patient is securely strapped to the short spine board, you can remove the patient from the vehicle. The safest way to do this is to rotate the patient carefully and slide him or her onto a long spine board. The long board should be positioned so that one end is resting firmly on the seat and the other end is held parallel to the ground. Lower the patient carefully into a supine position and slide him or her gently along the long board. You will need to loosen the straps on the short board momentarily to lower the patient's legs.
- Two rescuers should lift the patient out of the vehicle, one holding the patient's trunk and the other supporting the patient at the underarms. Never lift a patient by pulling up on the short spine board.

Patients injured in different types of accidents require different measures for extrication and spinal immobilization, but the basic principles are the same. The patient injured in a diving accident, for example, often has a cervical spine injury and must be approached with that possibility in mind. If the patient is still in the water, the procedure is as follows:

- Approach the patient from the vertex. The first rescuer should place one arm under the patient's body so that the patient's head is supported on the rescuer's hand. The rescuer should place the other arm across the patient's head and back, thus splinting the patient's head and neck between the rescuer's arms.

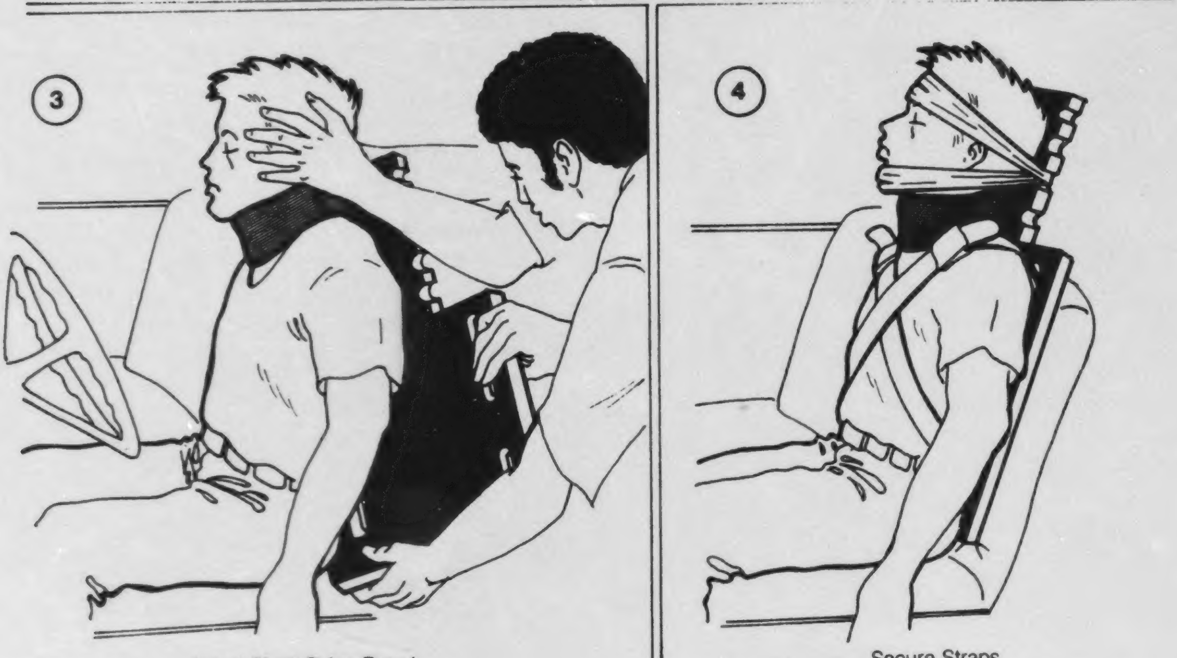
- Turn the patient smoothly into the supine position while maintaining support on the head and neck. If the patient is not breathing, begin mouth-to-mouth resuscitation immediately, while the patient is still in the water.

- Slide a rigid device—such as a wooden spine board, surfboard, door, or wooden plank—under the patient's head and neck. A cervical collar or other device can then be applied to stabilize the neck further.



Maintain Traction

Apply Collar



Insert Short Spine Board

Secure Straps

**Figure 22.** **Paramedic Maintaining Axial Traction of the Automobile Accident Victim**

- Float the board to the edge of the water and lift it out. One rescuer should stabilize the patient on the board to prevent undue motion.
- After the board is removed from the water, strap the patient to it. An inflatable splint can be passed gently behind the patient's neck and inflated to serve as a neck roll. Then stabilize the patient with roller bandages or sandbags.

### Monitoring Patient Status

As was noted earlier, the key to assessment of patients with CNS problems is repeated observation. Such observation is easier and more accurate if you use a checklist that charts neurologic signs over time. Whether you use the checklist developed by the American College of Surgeons or another one, it is important to use some type of form to record repeated observations of the patient's neurological function.

## Glossary

**aura:** A premonitory sensation of impending illness; a word usually used in connection with an epileptic attack.

**Battle's sign:** Purplish discoloration (ecchymosis) above the bone behind the ear (mastoid process) indicating a basilar skull fracture.

**central neurogenic hyperventilation:** An abnormal pattern of ventilation seen in severe illness or injury involving the brain; characterized by marked excessively rapid breathing (tachypnea) and exceptionally deep breathing (hyperpnea).

**cerebellum:** That portion of the brain behind and below the cortex; its general function is the coordination of movement.

**cerebrum:** The main portion of the brain, occupying the upper and anterior part of the cranial cavity; site of voluntary motor control, the conscious will, and the emotions.

**Cheyne-Stokes respiration:** An abnormal breathing pattern characterized by rhythmic waxing and waning of the depth of respiration with regularly recurring periods of apnea; seen in association with central nervous system dysfunction.

**clonic:** Pertaining to the rapid contraction and relaxation of a muscle or group of muscles.

**cranium:** The skull.

**doll's eye:** The phenomenon in which the eyes of an unconscious person move in the direction opposite to that in which the head is turned.

**dysarthria:** A defective speech pattern due to impairment of the tongue or other muscles needed for speech.

**extraocular movements:** The movements of the eye.

**focal motor seizure:** A seizure that is usually limited to one side of the body or one body part, such as an arm.

**grand mal seizure:** A generalized motor seizure characterized by loss of consciousness; tonic-clonic movements; and, sometimes, tongue biting, incontinence, and mental confusion.

**hemiparesis:** A weakness on one side of the body.

**hemiplegia:** A paralysis of one side of the body.

**idiopathic:** Of unknown cause.

**medulla oblongata:** The portion of the brain between the cerebellum and the spinal cord that contains the centers for control of respiration and heart beat.

**motor aphasia:** The inability to coordinate the muscles involved in speech; caused by damage to the brain center that controls speech (Broca's area).

**paralysis:** A loss of motor function.

**paraplegia:** The loss of both motion and sensation in the lower part of the body, most commonly due to damage to the spinal cord.

**petit mal seizure:** A type of epileptic attack; characterized by a momentary loss of awareness that is not accompanied by a loss of motor tone.

**postictal:** Referring to the period following the convulsive stage of a seizure.

**psychomotor seizure:** A seizure characterized by an altered personality state; in some patients, psychomotor seizures result in unexplained attacks of rage or stereotyped behavior.

**quadriplegia:** A paralysis of both arms and legs.

**raccoon sign:** The bilateral, symmetrical, bruising around the eyes (periorbital ecchymosis) seen with skull fracture; also called "coon's eyes."

**sensory aphasia:** The inability to understand spoken or written words, depending on which word center is dysfunctional.

**status epilepticus:** The occurrence of two or more seizures without a period of complete consciousness between them.

**sympathetic nervous system:** A subdivision of the autonomic nervous system that governs the body's "fight or flight" reactions and stimulates cardiac activity.

**tonic:** Pertaining to the period in a seizure in which the muscles contract and do not relax.

**transient ischemic attack (TIA):** A temporary condition in which the blood supply to the brain is interfered with; usually an indication of an impending stroke.

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## Module VIII.
# Soft—Tissue Injuries

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# Module VIII.

# Soft-Tissue Injuries

## Unit 1. Anatomy and Physiology of the Skin

The skin and its derivatives (hair, fingernails, and sweat glands) constitute one of the most complex and important systems of the body. It serves a variety of crucial functions:

- The skin protects underlying tissue from injury caused by temperature extremes, physical impact, and chemical or bacterial sources.
- The skin aids in temperature regulation. It prevents heat loss when the core body temperature falls and aids heat loss when the core body temperature rises.
- The skin acts as a watertight seal. It prevents excessive water loss and drying of the tissues and thus helps to maintain the stability of the body's internal environment (homeostasis).
- The skin serves as a sensory organ. Changes in temperature and body position and sensations of pain are picked up through the skin and sent through the nerves to the brain.

Thus, significant damage to the skin leaves the body open to invasion by bacterial agents, to marked temperature changes, and to major disturbances in fluid balance.

The skin is composed of two principal layers, the epidermis and the dermis, as shown in Figure 8.1. The epidermis, or outermost layer, is the body's first line of defense. The outer cells of the epidermis are nonliving, hardened (cornified) cells that are constantly being shed through a process called desquamation. The deeper layers of epidermis include a varying number of cells containing melanin granules; melanin is a pigment that is responsible for skin color. Underlying the epidermis is a tough, highly elastic layer of connective tissue called the dermis. This layer contains many specialized skin structures (see Fig. 8.1). A list of these structures and a brief description of their functions follow:

- **Nerve endings** mediate the sense of touch and the perception of temperature, pressure, and pain.

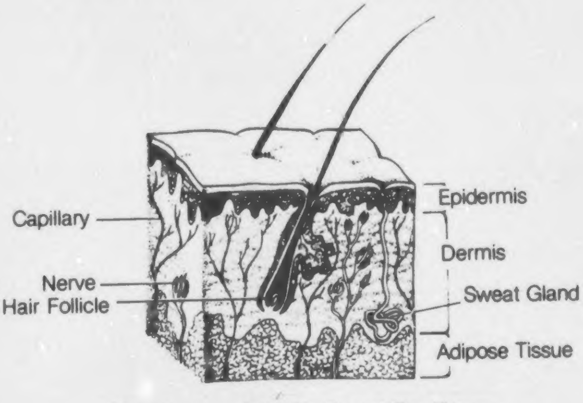

**Figure 1. Skin in Cross-Section**

- **Blood vessels** carry oxygen and nutrients to the skin and remove carbon dioxide and metabolic waste products.
- **Sweat glands** produce sweat and discharge it through ducts that extend to the surface of the skin. Action of the sweat glands is regulated through the sympathetic nervous system.
- **Sebaceous glands** secrete an oily substance called sebum. Sebum is important in maintaining the suppleness of the skin and in keeping the skin waterproof. Sebaceous glands usually open into a hair follicle and discharge their contents along the hair shafts.
- **Hair follicles** produce hair and enclose the hair roots. Each follicle contains a single hair. Attached to the hair follicle is a small muscle that, on contraction, causes the follicle to assume a more vertical position. Sensations such as cold and fright produce impulses through the autonomic nervous system that bring about contraction of these muscles. The result is the bumpy appearance of the skin known as "goose flesh."

## Unit 2. Patient Assessment

No matter what the underlying problem or complaint, the assessment of every patient includes examination of the skin. This evaluation provides important information about the patient's state of peripheral perfusion.

The color of the skin, especially in lightly pigmented patients, reflects the condition of circulation immediately underlying the skin (the cutaneous circulation), as well as the oxygen saturation of the blood. In darkly pigmented individuals, such changes may not be readily visible in the skin, but may be assessed by examining the mucous membranes of the mouth or conjunctiva.

**Table 8.1**

**Possible Causes of Variations in Skin Color**

| Skin Color | Possible Cause |
|---|---|
| Red | Vasodilation, fever or allergic reactions, abnormal state of hemoglobin due to carbon monoxide poisoning. |
| White (pallor) | Vasoconstriction due to excessive blood loss, fright, or anemia. |
| Blue | Oxygen desaturation (hypoxia, vasoconstriction) due to cold or shock. |
| Mottled | Cardiovascular embarrassment (as in shock). |

If the cutaneous blood vessels constrict (vasoconstriction) or blood flow decreases, the skin becomes cool, moist, and pale. It also may appear mottled (varied in color) or eventually become bluish or grayish (cyanotic). If cutaneous vessels dilate (vasodilation) or blood flow increases, the skin becomes warm and pink. Pallor—a loss of color—occurs when arterial blood flow ceases after extensive hemorrhage. The variations in skin color and possible causes are summarized in Table 8.1.

Skin temperature rises as peripheral blood vessels (those closest to the skin) dilate, and it falls as the blood vessels constrict. Therefore, fever and high environmental temperatures that lead to vasodilation will cause skin temperature to rise. Shock, which leads to vasoconstriction, will cause skin temperature to fall under most circumstances. Normal skin is fairly dry. Stimulation of the sympathetic nervous system, as in shock, causes sweating (diaphoresis) and moist skin. Depression of the sympathetic nervous system occurring in patients with injury to the thoracic or lumbar spine can cause the skin in affected areas to become abnormally dry and cool. Variations in skin temperature and possible causes are summarized in Table 8.2.

**Table 8.2**

**Possible Causes of Variations in Skin Temperature**

| Skin Temperature | Possible Cause |
|---|---|
| Hot, dry | Excessive body heat (e.g., from heat stroke). |
| Hot, wet | Reaction to increased internal or external temperature. |
| Cool, dry | Exposure to cold. |
| Cool, clammy | Shock. |

In the injured patient, the skin can be the site of damage as well as an indicator of peripheral perfusion. Soft-tissue injuries include those that damage the skin itself, as well as the subcutaneous tissue and muscle. The skin can be damaged by sharp or blunt objects as well as by falls or collisions with stationary objects. Skin and subcutaneous tissue also can be injured by extremes of temperature, chemical substances, radiation, and electricity. Injuries to the skin and soft tissues can be of particular concern in certain areas because of the underlying vital structures. For example, injuries to the abdominal wall can also injure the liver, spleen, or pancreas in the upper abdomen; back injuries can damage the kidneys; and lower abdominal trauma can injure the bladder. It also is possible to injure hollow organs, such as the small intestine and large intestine, by sudden injuries to the abdominal wall. Soft-tissue injuries near the eye, ear, and nose should alert you, the Emergency Medical Technician-Paramedic (EMT-P), to the possibility of more serious injuries to the underlying structures. This possibility is also true of injuries to the throat and neck where serious injuries to the blood vessels and the trachea can occur.

It is important to remember that, although the signs of soft-tissue injuries usually are very obvious and may distort the body dramatically, most other injuries take priority over soft-tissue injuries. Soft-tissue injuries are usually not the most serious injuries unless they compromise the airway or are associated with severe hemorrhage. Thus, you must search systematically and thoroughly for other injuries or life-threatening conditions before tending to the external soft-tissue trauma. Conduct the primary survey first. Treating any life-threatening injury, and then do a secondary head-to-toe survey. Trying to determine the cause of the injury will frequently provide clues to the severity and the extent of the injury. This information can be used to determine appropriate treatment. Evidence of contact with extreme heat or cold, as well as contact with electricity and chemical substances, should be noted.

If external hemorrhage is present, note the nature and color of the blood. Is it coming in a steady flow (venous blood) or spurts (arterial blood)? Are signs of shock present? Look for the following signs of internal hemorrhage: restlessness and anxiety; weak, rapid pulse; cold, clammy skin; diaphoresis; and falling blood pressure.

Also watch for discolorations of the skin that would indicate such acute conditions as ecchymosis (purplish mark due to blood escaping into the tissue) and hematoma. Areas of swelling also should be noted as well as any breaks in the skin, no matter how small. Soft-tissue injuries can range from breaks in the skin, such as abrasions or lacerations, to major tissue damage resulting from severe crushing injuries and amputations. During the secondary survey, look for cerebrospinal fluid draining from the ear or nose; such a condition may indicate serious injuries within the skull. And any associated injury, like a fracture, should be noted and treated.

## Unit 3. Pathophysiology and Management of Soft-Tissue Injuries

Soft-tissue injuries are categorized for the purpose of this unit as mechanical injuries and burns.

### Mechanical Injuries

Soft-tissue injuries involve the skin and usually are classified as closed or open. In a closed injury, such as a bruise or contusion, there is damage to the soft tissue beneath the skin but no actual break in the skin. Contusions are marked by local pain and swelling. If small blood vessels beneath the skin have been broken, there will be ecchymosis as well. If large vessels have been torn beneath the contused area, a hematoma, or collection of blood beneath the skin, will be evident as a lump with bluish discoloration. Closed wounds should be treated with pressure and cold applications to minimize edema but otherwise require no specific treatment.

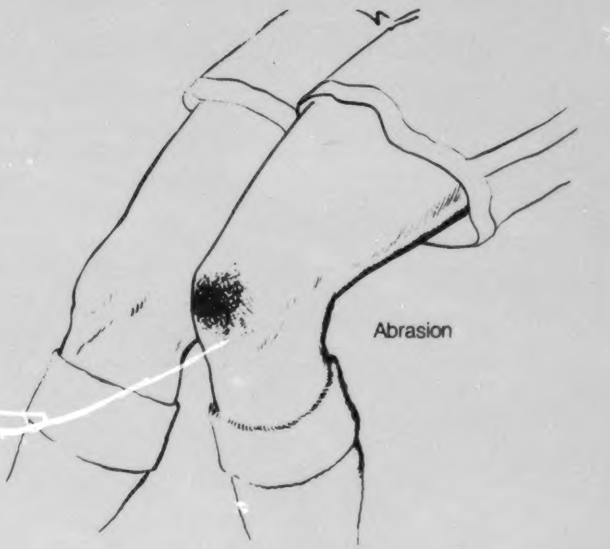

**Figure 2. An Abrasion**

An open wound is one in which there is disruption in the continuity of the skin and, therefore, is susceptible to external hemmorrhage and contamination. Open wounds may be of several types.

An abrasion, as shown in Figure 8.2, is a superficial wound caused by rubbing or scraping, resulting in partial loss of the skin surface.

A laceration, as illustrated in Figure 8.3, is a cut made by a sharp instrument, such as a knife or razor blade,

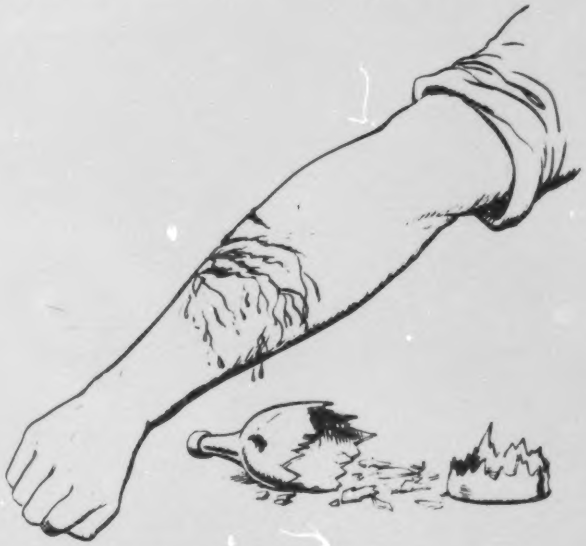

**Figure 3. Laceration**

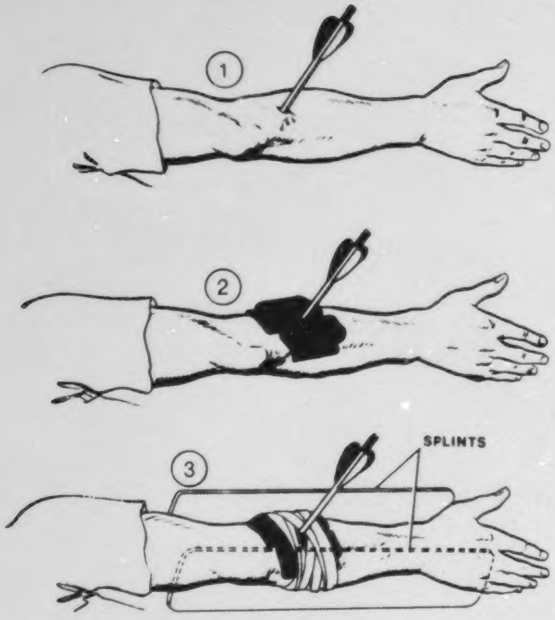

**Figure 4. Method for Managing a Puncture Wound**

that produces a clean or jagged incision through the skin surface and underlying structures. A laceration can be the source of significant bleeding if the sharp instrument also has disrupted the wall of a blood vessel, particularly an artery. Thus, significant bleeding can result from lacerations in regions of the body where major arteries lie close to the surface, such as in the wrists.

A puncture wound is a stab from a pointed object, such as a nail, ice pick, or knife. Special treatment of the puncture wound is required when the object causing the injury remains impacted in the wound, as illustrated in Figure 8.4. A discussion of this type of wound is provided in the section concerning impaled foreign objects.

An avulsion is the tearing of a patch of skin or other tissue that if not totally torn from the body creates a loose, hanging flap. An automobile accident in which the victim is thrown through the windshield can result in a commonly seen avulsion of the forehead, as shown in Figure 8.5. Avulsions also can involve such body parts as eyeballs, ears, fingers, or hands. In these situations, the paramedic should wrap the avulsed part in gauze soaked in a sterile saline solution, iced if possible.

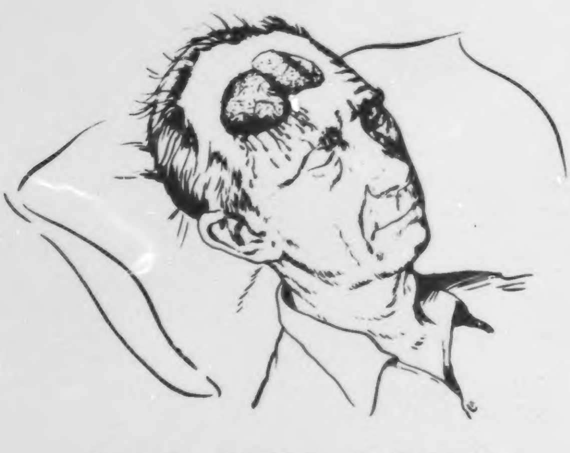

**Figure 5. Avulsion of the Forehead**

Treatment of open wounds should be directed toward controlling hemorrhage and preventing contamination and further injury.

Hemorrhage can be controlled by direct pressure over the wound. If bleeding is severe, a sterile pressure dressing should be placed over the wound, and compression should be maintained either manually, with bandages, or with an airsplint inflated over the dressing. Massive hemorrhage from the lower extremities can be controlled with the Military Antishock Trousers (MAST).

The wound should be kept as clean as possible. It may be necessary to cut away any clothing covering the wound. If the trip to the hospital is likely to take a long time, loose dirt and debris can be removed from the wound by irrigation—the pouring of sterile water over the area. Foreign matter embedded in the wound, however, should not be picked out. Simply irrigate the wound with large amounts of sterile saline and cover it with a dry sterile dressing. If a hospital is within 5 to 10 minutes' traveling time, apply a sterile dressing and transport the patient to the hospital.

Stabilizing open wounds in which foreign objects are impaled requires additional treatment. Observe the following guidelines for treating these injuries:

- Do not remove an impaled object. Efforts to do so can cause severe hemorrhage and do further injury to underlying structures. The only exception to this rule is when the impaled object interferes with airway management.
- Control hemorrhage by direct compression, but do not apply pressure to the impaled object itself or to immediately adjacent tissues.
- Do not try to shorten an impaled object unless it is extremely unwieldly (e.g., a fencepost protruding from the chest). Remember that moving the object may cause further damage to nerves, blood vessels, and other surrounding tissues. Stabilize the impaled object with a bulky dressing that is bandaged in place.

Amputation of a body part is another type of open wound that may be encountered. An amputation is the severing of a body part such as a finger, hand, or arm. In some cases, the severing may be incomplete, leaving a few strands of tissue connecting the body parts. Hemorrhage from complete or incomplete amputation can be severe. When treating hemorrhage associated with amputation, follow the same course of action you would for other open wounds. A tourniquet should be used to control the bleeding only as a last resort; it can irreversibly damage other tissue. The amputated segment should be wrapped in gauze well soaked with sterile saline, placed in a sterile saline solution (iced if possible), and brought to the medical facility.

## Burns

Burns can be caused by exposure to heat or extreme cold, exposure to caustic chemicals, contact with sources of electrical current, or exposure to radioactive materials.

### THERMAL BURNS.

In the examination of the burned patient, the paramedic must determine the depth and degree of damage to the skin and underlying tissues. This information is vital when treating patients requiring triage.

Classification of burns—Thermal burns are classified as first degree, second degree, or third degree according to the depth of tissue injury they produce.

First-degree burns damage only the most superficial layers of the skin. Such burns produce redness and pain, as in a scald or moderate sunburn. They are painful initially, but usually heal in about a week, after the outer epidermal layers peel off.

Second-degree burns penetrate deeper into the skin than first-degree burns and produce pain and blistering as well as some subcutaneous edema. Until blisters form several hours after the injury, the skin is red and mottled. Such burns are characterized by severe pain because nerve endings become irritated and hypersensitive to pressure or other stimulation. Significant tissue fluid loss through damaged skin can result from second-degree burns. If the burn is kept clean and does not become infected, however, it will usually heal in 2 to 3 weeks. Second-degree burns are most often caused by contact with boiling liquids.

Third-degree burns involve damage or destruction of the full thickness of the skin. Such burns can involve underlying muscle, bone, and other structures as well. The skin is pale and dry and may appear charred and leathery. Pain is usually absent due to destruction of nerve endings. As damaged skin cannot perform its usual protective function, patients with third-degree burns are likely to undergo rapid and significant fluid loss. Therefore, shock is a major problem in these patients. Treatment of third-degree burns usually requires skin grafting.

The "rule of nines" is used to estimate the percentage of the body surface burned. Tables are available to assess the severity of the burn using this rule, as shown in Figure 8.6. The severity of burns relates principally to the depth and amount of the skin affected.

Critical burns are those that involve any of the following factors:

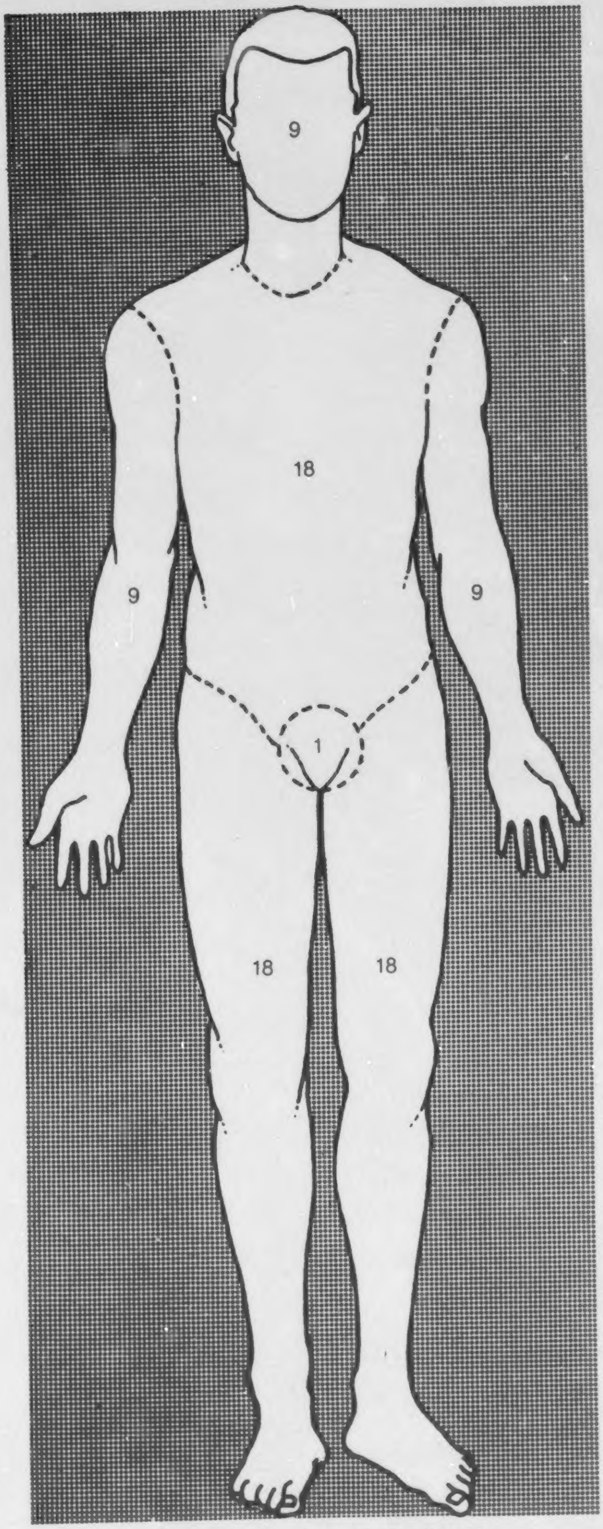

Figure 6. "Rules of Nines"

- Second-degree burns involving more than 30 percent of the body surface.
- Third-degree burns of more than 10 percent of the body surface.

- Burns complicated by respiratory injuries.
- Almost all burns of the face, hands, or feet.
- Burns complicated by fracture or major soft-tissue injury.
- Electrical and deep acid burns. (See next section.)
- Burns occurring in patients with serious underlying physical problems (e.g., a heart condition).

Moderate burns include second-degree burns that involve 15 to 30 percent of the body surface and third-degree burns that involve 2 to 10 percent of the body surface, excluding burns of the hands, feet, and face.

Minor burns include second-degree burns that affect less than 15 percent of the body surface; third-degree burns that affect less than 2 percent of the body surface; and first-degree burns that affect less than 20 percent of the body surface, excluding hands, feet, and face.

In addition to the depth and extent of the burn, the age of the patient is a very important determinant of burn severity. In children (under 2 years) and in patients over 60 years of age, the mortality associated with even small burns rises sharply.

Management of thermal burns in the field—For effective management of the burn patient, a good history should be taken. Always obtain the following information:

- How long ago did the burn occur?
- What, if anything, has been done by the patient or bystanders for the injury?
- Was the patient confined in a closed space with smoke, steam, or other products of combustion? If so, for how long? Did the patient lose consciousness?
- With what was the patient burned—open flame, hot liquids, or chemicals?
- Does the patient have any history of significant heart disease that might complicate fluid therapy? Is there a history of pulmonary problems that might cause a more severe reaction to smoke inhalation? Are there any other serious underlying illnesses, such as diabetes?
- Does the patient have any allergies, including allergies to any medications?

First-degree burns can be painful, but are usually not fatal, unless very large areas of the body are involved. Within 15 to 30 minutes of the injury, immerse the burned area in ice water, if available. Ice compresses can also be used. Soak burned hands and feet directly in ice water. Apply cold, wet towels to burns of the face and trunk. A dry, sterile dressing or sheet should then be placed over the burned area. Burns should never be treated with salves, ointments, butter, creams, sprays, or any coverings other than a dry, sterile dressing. These would only have to be scrubbed off in the emergency department. Usually, no further in-the-field treatment is necessary for the limited first-degree burn. Transport the patient to the hospital in a comfortable position.

Treatment of second-degree burns is very similar to that of first-degree burns. The burned area should be immersed in ice water or treated with cold compresses. If performed within the first 30 minutes following the burn, this procedure can diminish edema and provide significant pain relief. Do not attempt to rupture blisters over the burn. Blisters make an excellent dressing. If second-degree burns cover more than 15 percent of the body or are accompanied by first-degree burns covering more than 30 to 50 percent of the body, intravenous (I.V.) fluids should be started. Starting an I.V. on a burned patient may present a problem, since the usual sites for the I.V. may be involved in the burn. If both arms are completely burned, the I.V. can be started in a vein in the foot. If necessary, however, the I.V. can be started in the burned area. In general, dextrose in normal saline (D5NS) or dextrose in Ringer's solution should be given to adults at a rate of about 250 milliliters (ml) per hour. Elderly patients, infants, or patients with a history of heart problems will require appropriate adjustments in I.V. rate.

The first act in treating a burn victim is to extinguish any clothing on fire. Stop a person whose clothes are on fire from running; running does not put out the fire, but serves to fan the flames. Nor should the person remain standing, because a standing victim is more apt to inhale flames and to ignite the hair in this position. Place the patient on the floor or ground and smother the flames by the fastest possible means. The patient can be rolled in a blanket or doused with large quantities of water. Once the fire is dead, remove all smoldering clothing; the burning may continue if the clothing is left on. Any other articles that may retain heat, such as jewelry, also should be removed.

As in any critical injury, the airway is the most important initial consideration in the severely burned patient. Respiratory problems can be anticipated if the victim has:

- Burns around the face.
- Been unconscious in a burning area.
- Been exposed to smoke or hot gases, especially if the burn occurred in a closed space.
- Singed nasal hair.
- Hoarseness or cyanosis.

Every patient who has inhaled smoke or who is in shock should receive oxygen. Laryngeal edema may develop with alarming rapidity, especially in the infant or child. Early intubation may be lifesaving in such cases. Give the physician detailed information on the patient's current respiratory status, whether the patient was unconscious, and whether there are burns about the face and neck so that the appropriate decisions about intubation can be made. Bear in mind that intubation of a conscious, anxious patient in the field can be very difficult. Damage can be inflicted on the airway if the patient is struggling. If intubation becomes necessary under these circumstances, however, explain carefully to the patient what is proposed, why it is necessary, and how he or she can best cooperate. All the equipment should be set up at the patient's side so that intubation, once begun, proceeds rapidly and smoothly.

A major problem in the severely burned patient is acute gastric dilation, which may itself cause respiratory embarrassment. In the intubated patient, a nasogastric tube may be necessary to decompress the stomach. A nasogastric tube should not be used in a stuporous or comatose patient who has not been intubated or in a patient with severe thermal injury involving the nasopharynx. Such patients may vomit and aspirate gastric contents into their lungs.

When treating severely burned patients, perform the following steps:

- Be aware of the possibility of major fluid loss.
- Record vital signs and reassess them frequently, since an increasing pulse may be the first indication of impending shock.
- Start an I.V., if available, in patients with third-degree burns covering more than 10 percent of the body or with extensive burns of varying degrees. Use normal saline or Ringer's solution at the rate of 250 to 350 milliliters per hour.
- Anticipate shock, and keep the patient flat.
- Look carefully for associated injuries, which can be obscured in the burned patient; look especially for eye injuries, and cover them with moist, sterile pads.
- Check pulses in all extremities, since edema of circumferential burns (burns that encircle an extremity) can act as a tourniquet and would thus decrease or stop circulation to the limb (this situation ultimately will produce ischemia); in the field, cool any limb without a pulse with ice compresses or cold packs.
- Never waste time trying to pick debris off the skin; simply cover the patient with a sterile sheet or clean dressing.
- Remove rings, bracelets, and other potentially constricting items as soon as possible because swelling of the hands and fingers may occur rapidly after a burn.
- Treat and immobilize associated fractures, lacerations, and other injuries in the usual fashion.

Burns in infants and small children pose special problems because a larger portion of their surface area is involved compared with their total body mass, and thus potential fluid loss through extensive burns can be great. In the case of a seriously burned infant, take the following steps:

- Start an I.V., if at all possible, using a 21-gauge wingtipped infusion needle.
- Hang the smallest bag of normal saline with a microdrip infusion apparatus.
- Use an infusion rate of 15 milliliters per hour for neonates and 30 milliliters per hour for the infant 6 to 12 months old.
- Monitor the I.V. carefully, making sure that it does not run wide open.
- Increase the infusion rate if the patient's blood pressure is less than 90 systolic.
- If unable to start an I.V.:
  —Wrap the infant in a moist sterile sheet;
  —Cover the sheet with blankets to keep the infant warm;
  —Transport the infant to the hospital as rapidly as possible.

## Chemical burns

Chemical burns occur when the skin comes in contact with strong acids, alkalis, or other corrosive materials. The burn will progress as long as the corrosive substance remains in contact with the skin. Thus, the cornerstone of therapy for these burns is removal of the chemical from contact with the patient's body. Chemical burns can be caused by contact with wet or dry chemicals. In general, all wet chemicals should be flushed with water. Dry chemicals should be brushed away unless large quantities of water are available.

Speed is essential. When patients have been exposed to dangerous chemicals, take the following steps immediately:

- Flush the area with large amounts of water for 5 minutes. If the patient is in or around the home, a shower or garden hose is ideal for this purpose.
- Quickly remove any of the patient's clothing that may be contaminated with the chemical, especially shoes and socks.
- Flush with water for 20 to 30 minutes.
- Rinse the affected area with a dilute vinegar solution for alkali burns or a baking soda solution (1 teaspoon of baking soda per pint of water) for acid burns.
- Avoid wasting time looking for specific antidotes. Flushing with water is usually more effective except in special cases in which burns are caused by chemicals that are insoluble in water.
- Prevent personal injury by avoiding skin or clothing contact with the dangerous chemical.

Take the following measures if chemicals have been splashed into the eyes:

- Have the patient remove contact lenses as soon as possible. Contact lenses can prevent irrigants from reaching the underlying cornea.

- If acid is the irritant, flush the eyes with large amounts of water for at least 5 minutes; if alkalis, 15 minutes. Irrigate thoroughly beneath the lids.
- Do not use any antidote, such as vinegar, baking soda, or alcohol, in the eyes.
- Cover the burned area with a sterile dressing.
- Transport the patient to the hospital.

Chemical burns also are caused by substances that are not water soluble or can cause adverse reactions when mixed with water:

- Dry lime will produce a highly corrosive substance when combined with water. For this reason, remove the patient's clothing and brush the lime from the skin, unless a large quantity of water—such as from a garden hose—is immediately available for flushing. Just a small amount of water will do more harm than good.
- Because phenol (carbolic acid) is not water soluble, water irrigation alone is largely ineffective. Phenol is, however, alcohol soluble, and therefore the affected area should be washed with any available alcohol (rubbing alcohol, gin, or whiskey) before prolonged flushing with water. If alcohol is unavailable, prolonged flushing with large amounts of water is preferable to no treatment at all.
- When mixed with water, sodium metals and sulfuric acid produce considerable heat and are potentially explosive. Unless a hose or shower is available, when dealing with these agents, avoid flushing with water. Cover burns caused by sodium metals with oil; this will stop the reaction. Areas exposed to sulfuric acid should be washed down with soap to neutralize the acid.

**Electrical burns.**

Electrical injuries differ from thermal injuries in the following ways:

- The resistance of tissue to the passage of a high-voltage current through it generates extreme heat causing both an entry and exit surface burn. Thermal burns damage tissue only from the outside at the location of initial exposure.
- Electric current takes an unpredictable course through the body.
- Changes in the heart, central nervous system, and muscles.
- Variation in response of the individual tissues.

Serious electrical injuries account for 3 to 5 percent of major burn admissions. Since more of these major injuries are being successfully managed at the scene of the accident, the number of these severely injured patients reaching burn centers has increased. Factors determining the severity of electrical burns include the amount (intensity) and the duration of the current. Levels of 60 to 65 volts can be fatal.

The skin is nonconductive to low-voltage electricity. Resistance, however, becomes lower if the skin is broken or if the skin is moist. Internal body resistance to electricity is low; therefore extensive internal damage usually occurs. Electricity is converted into heat as it travels from the point of contact. Inside the body, the current follows the natural anatomical flow of blood vessels, nerve branches, and so forth, resulting in extensive internal damage to such structures as the heart and kidneys. Low voltage follows the path of least resistance, which is usually the blood vessels. High voltage follows the shortest path. It must be remembered that initial clinical findings may not reveal the extent of internal damage. (For further discussion, see section on contact burns.)

Electrical injuries can be caused by alternating current or direct current. Alternating current produces more dangerous reactions because it causes tetanic spasms (severe contractions) that can immobilize the patient. Electrical flow causes the muscles to contract and can cause the patient to be immobilized to the source of the current. Thus, more serious injury is sustained by flexor surfaces. An average let-go current is 8 to 22 milliamperes.

## CLASSIFICATION OF ELECTRICAL BURNS.

The three major types of electrical burns are contact burns, flash burns, and flame burns.

Contact burns usually occur at two sites: where the electrical current enters and where it leaves the body. There may be serious skin damage at either of these points and variable degrees of superficial or deep tissue loss between the points of entrance and exit. The typical entrance wound is charred and depressed; and the blisters, which are produced by evaporation of tissue fluid, may end in total evaporation and charring of the blister walls. The entrance lesion may resemble a bull's-eye with a central charred zone of third-degree burns; a middle zone of cold, gray tissue; and an outer red zone of coagulation necrosis. The exit wounds are usually dry and circumscribed. Deep tissue damage between the entrance and exit wounds may be extensive and is evidenced by swelling in these areas.

The body serves as a conduit for passage of the electrical current from the point of contact to the ground. The passage of current and the resistance of tissue to the passage cause the electrical energy to be converted into heat energy. In general, the flow of current from the point of entrance to the point of exit is along the lines of least resistance, and, thus, vascular and neural damage are much more common than muscle or bone damage. If the current passes through the skin or the surface tissue, arcing (the movement of current from one body part to another without passing through it) of the current is seen at flexor surfaces, where the current does not damage the intervening tissue. The antecubital fossa and the axillae are examples of where skipped areas may be evident.

Flash burns usually are due to an arc of electricity and not to the passage of a current through the body. Although the duration of the flash may be brief, it usually causes extensive superficial injuries. The deep neural and vascular damage caused by the passage of current through the body is not found in flash burns.

Flame burns result when clothing or objects in direct contact with the skin are ignited by an electrical current. These injuries are caused by the flames produced by the electrical current and not by the passage of the electrical current or arc.

It is important to recognize these three forms of injury fairly early, since treatment emphasis will vary depending on the type of burn.

### INITIAL MANAGEMENT OF ELECTRICAL BURNS.

At the scene of the accident, keep two factors in mind:

- The patient may still be in contact with the source of the current. Do not endanger yourself by touching the patient, metal objects, water, or wet ground. Use special lineman's gloves, a hot stick, or a polydacron rope to remove the patient from the source of the current.
- Cerebral and cardiorespiratory arrest resulting from the initial injury is reversible. Immediate cardiopulmonary resuscitation can save patients who appear dead from cardiac standstill. As soon as the patient is removed from the source of the injury and cardiorespiratory status is stabilized, he or she should be transported to the nearest medical facility. If a medical facility cannot be reached within 5 minutes, I.V. fluids should be started without delay.

The care of patients with electrical injuries is aided by the recognition of the types of cutaneous and deep injuries and by the early diagnosis of vascular, neural, and muscle damage. In most cases, cardiorespiratory arrest at the scene of the accident can be reversed by prompt treatment. A very aggressive program of rapid and adequate resuscitation, diagnosis of the type of injury, and treatment in a hospital where total care is available can save a large number of these patients and reduce the possibility of complications.

## Unit 4. Techniques of Management

### Dressing and Bandaging

Dressings are used to control bleeding and to prevent contamination. Bandages are used to hold dressings in place. There are many different kinds of dressings. Sterile gauzes and pressure dressings are the most commonly used. When these are unavailable, nonsterile substitutes such as sanitary napkins, bed sheets, towels, or handkerchiefs are acceptable. There are also many different kinds of bandages. Self-adhering and formfitting bandages have considerable advantages over the old roller gauze bandages.

Bandages need not be pretty or be textbook perfect as long as they hold the dressings in place. Care should be taken, however, so that bandages are not applied too tightly or too loosely. Bandages that are too tight will restrict the flow of blood, and bandages that are too loose will not hold the dressing in place. When extremities are bandaged, the fingers and toes should be left exposed so that any color changes in them can be noted.

### External Hemorrhage

Bleeding from a wound in the skin is defined as external hemorrhage. A hemorrhage can be characterized by the type of blood vessel that has been damaged. Arterial hemorrhage occurs in spurts, and the blood is often bright red in color. Venous hemorrhage is more likely to be slow and steady, and the color of the blood is darker. In most wounds a combination of arterial and venous bleeding occurs. Besides respiratory and cardiac problems, hemorrhage is the most important factor to look for when treating soft-tissue injuries. Average adults have 12 pints of blood in their bodies. Distribution of blood is shown in Figure 8.7. The loss of 2 pints in an average adult can lead to shock.

The use of instruments such as hemostats and elastic bandages (Ace bandages) should be minimized. The use of the carotid pressure point is of questionable value. If it is to be used, caution must be exercised. Pressure should not be applied to both carotids at the same time since such occlusion may restrict blood flow to the brain. External hemorrhage may be controlled in several ways:

- When external hemorrhage occurs from an extremity, elevate the extremity.

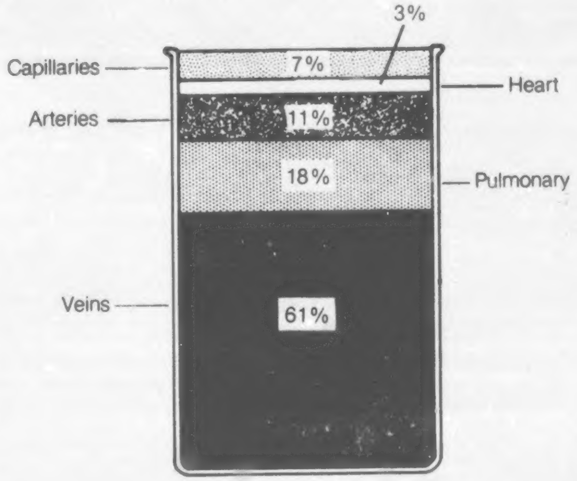

**Figure 7. Distribution of Blood in the Body**

- Steady, direct pressure against the bleeding site is the most effective method for controlling hemorrhage and should always be attempted first. Employ the following guidelines when performing this technique:

—If possible, use a sterile dressing; otherwise use a clean cloth or handkerchief.

—If no dressings are available, use the bare hand, thumb, or finger to apply pressure over the bleeding site.

—Maintain pressure until the bleeding stops or until the patient reaches the hospital and other medical personnel take responsibility for the patient's care.

—Resist the temptation to look at the wound. Removal of the dressing to see if the bleeding has stopped will usually start the blood flow again. If the blood has stopped running from under the dressing or the saturation has stopped, leave the wound alone.

- Pressure point control may be effective, especially when there are multiple bleeding sites supplied by the same artery or when it is impossible to reach the bleeding area. When an artery supplying an area of hemorrhage is superficial and overlies a hard structure against which it can be compressed, firm pressure on the artery may temporarily slow or halt distal bleeding. However, effective use of a pressure point will deny oxygenated blood to the tissues distal to the pressure point. This possibility must be weighed against the severity of the hemorrhage. The 11 pressure points located throughout the body are illustrated in Figure 8.8. The brachial, femoral, temporal, and facial pressure points are the major ones. To control hemorrhage, the brachial and femoral and possibly the carotid points are the most effective.

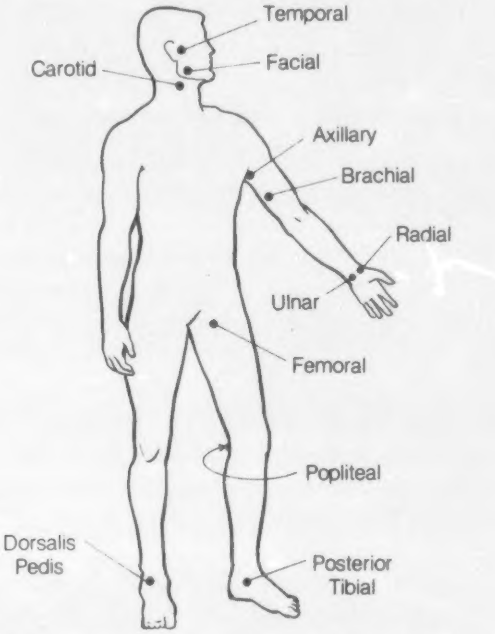

**Figure 8. Location of the 11 Pressure Points**

- A tourniquet should be used only as a last resort. The use of a tourniquet is rarely warranted, for control of hemorrhage can almost always be achieved by the above methods. Furthermore, use of a tourniquet is associated with several potential hazards, including damage to nerves and blood vessels; anaerobic metabolism with lactic acid buildup; and, when the tourniquet is in place for extended periods, loss of the distal extremity. In addition, a tourniquet applied too loosely may actually increase bleeding if venous return has been occluded without hampering arterial inflow. If it is determined that the use of a tourniquet is warranted, the paramedic should employ the following techniques:

—Use wide flat materials only, such as a cravat or folded handkerchief, as shown in Figure 8.9. Never use rope, wire, or other narrow materials that might cut into the skin and damage underlying tissues.

—Apply a pad over the artery to be compressed.

—Wrap the tourniquet twice around the extremity (about 4 inches below the axilla or groin), and tie half a knot.

—Place a stick, pencil, or similar object on top of the half knot. Tie the ends of the tourniquet in a square knot above the stick.

—Twist the stick or tighten the tourniquet until the bleeding stops, and no more. Secure the stick in that position.

—Never cover a tourniquet, since it may escape notice. When the patient has a tourniquet on, write "TK" on the forehead. Also, record the time the tourniquet was applied.

—Do not use a rubber tourniquet. It is seldom effective.

—Inject 50–100 milliequivalents (mEq) of sodium bicarbonate I.V. just prior to removal of the tourniquet.

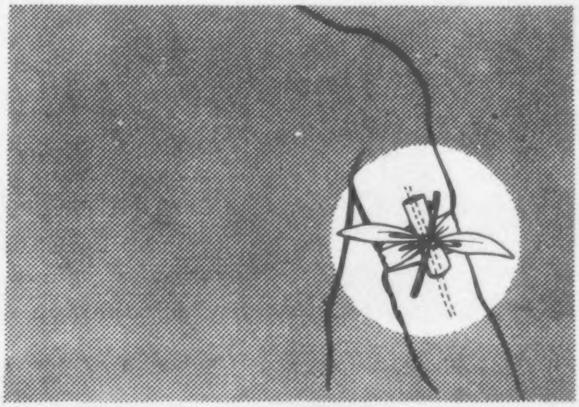

**Figure 9. Tourniquet Made from a Cravat**

—Remove the tourniquet if it has been put in place less than 15 minutes prior to the arrival of the Emergency Medical Services crew.

When significant external hemorrhage occurs from the lower extremities, the MAST provides an excellent means of *achieving hemostasis* through circumferential counter pressure.

## Internal Hemorrhage

Bleeding within the body often escapes attention because it is not immediately visible. However, several factors can signal significant internal hemorrhage:

- The mechanisms of injury—Patients with blunt abdominal trauma are likely to have considerable bleeding from injured abdominal organs and the blood vessels that supply them. Similarly, a patient with a femoral fracture may lose several units of blood into the thigh before the diameter of the thigh is increased noticeably or the hematoma is visible.
- The patient's medical history—The patient with a history of gastrointestinal ulcer or one who reports having vomited blood or passed blood by rectum may have lost a significant amount of blood internally.
- Physical signs suggestive of blood loss—These signs can include restlessness and anxiety; weak, rapid pulse; cold, clammy skin; shortness of breath; and, ultimately, a fall in blood pressure.

Internal hemorrhage involving the lower extremities and abdomen is best treated with the MAST. In addition, every patient with a significant internal or external hemorrhage should be given oxygen and I.V. replacement fluids, preferably colloid. If colloid is unavailable, normal saline or Ringer's solution can be used.

# Unit 5. Special Considerations in Soft-Tissue Injuries to Specific Areas

Soft-tissue injuries warrant special treatment, depending on the specific areas in which they occur.

## Emergencies Involving the Eye

There are few true ocular emergencies, but when they occur, they tend to be very urgent, and it is important to anticipate their presence in certain settings.

### ANATOMY AND PHYSIOLOGY OF THE EYE.

The eyes are globe shaped and approximately 1 inch in diameter. The globe shape is maintained by a jelly-like mass called vitreous fluid. This fluid cannot be replaced. If it is lost, the eye will be lost.

The important structures of the eye are presented in Figure 8.10. The light enters the eye through the cornea and then passes through the iris, which adjusts to the amount of light. Light then passes through the lens, and the muscles in the eye change the shape of the lens to focus the image on the retina. The light rays strike the retina, providing an upside-down image, and the optic nerve then transmits upright sensory images to the brain.

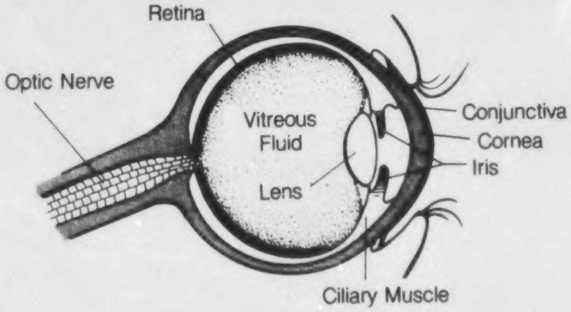

**Figure 10. Structures of the Eye**

As with all other patients, those with trauma or other medical problems involving the eye should be thoroughly questioned. The following kinds of information should be gathered: when the accident or pain occurred; what symptoms the patient noticed first; and whether both eyes were affected. Physical examination of the eyes should include:

- The orbits—for ecchymosis, swelling, laceration, and tenderness.
- The lids—for ecchymosis, swelling, or laceration.
- The conjunctivae—for redness, pus, or foreign bodies.
- The globe—for redness, abnormal pigmentation, laceration, and degree of hardness.
- Eye movements in all directions—for dysconjugate gaze, paralysis of gaze, or pain on movement.
- A rough assessment—for visual activity. The patient should be asked to read newsprint or to perform some other simple test. This last measure is extremely important, as it can greatly aid the emergency physician in a subsequent assessment of the patient.

### TRAUMA TO THE EYE.

Trauma to the eye can involve several types of injuries.

### INJURY TO THE ORBITS.

Trauma to the face may result in fracture of one or several of the bones of the skull that form the orbits (see Fig. 8.11). A patient with an orbital fracture may complain of double vision and may exhibit loss of sensation above the eyebrow or over the cheek due to associated nerve damage. In some cases, there may be a heavy nasal discharge of mucus; in others, mark-

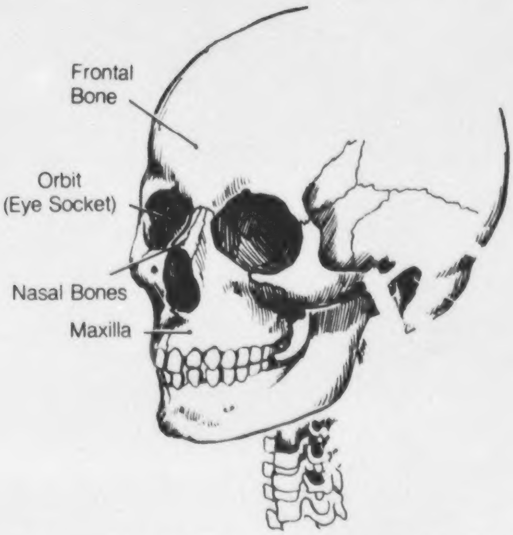

**Figure 11. Patient with Fractured Orbits**

edly decreased vision may occur. Fractures of the inferior orbit are the most common type and can cause paralysis of upward gaze (i.e., the patient's eyes will not be able to follow the paramedic's finger above the midline). Therefore, in the patient with possible facial fractures, it is important to check eye movements in all planes.

If there is no associated injury to the globe, ice packs may be used over the traumatized area to diminish swelling. Ice should not be used if globe injury is even suspected.

## LID INJURIES.

Lid injuries include ecchymosis, burns, and lacerations. In general, little can be done for these in the field beyond irrigation and gentle patching.

## INJURIES TO THE GLOBE.

Injuries caused by contusions, lacerations, foreign bodies, and abrasions usually are best treated in the emergency department, where specialized equipment is available. Patches lightly applied to both eyes are the only treatment measures usually necessary in the field. Cold compresses also may give some pain relief.

Chemical burns of the eye, especially alkaline burns, are treated differently, as such burns can lead to total blindness. When treating a patient with chemical burns to the eye, determine what caused the burn and, if possible, take the substance to the emergency department. Begin immediate, continuous irrigation with large amounts of saline or lactated Ringer's solution. It is not necessary that the irrigant be sterile. The affected eye should be continuously irrigated for a period of 30 to 60 minutes, starting immediately upon encountering the patient. Contact lenses must be removed or flushed out. It may be simplest to place the patient on his or her side on the stretcher, with a basin or towels under the head, and continuously direct fluid from I.V. bottles into the eye, while gently holding the lid open. Irrigation should be continued throughout transport. No irrigant other than water or saline should be used. Never irrigate the eye with any chemical antidote, including dilute vinegar, sodium bicarbonate, or alcohol.

A foreign object impaled in the globe should not be removed, but stabilized. Stabilization is most easily accomplished through the use of several layers of sterile gauze (4 by 4 inches) and a paper cup. The paramedic should:

- Cut a hole in the center of the dressing large enough to pass over the impaled object.
- Position the dressing over the injury site, taking care not to move the object.
- Position the inverted paper cup over the object and the dressing (the cup should be large enough to fit over the object without touching it).
- Fasten the cup in place with self-adherent roller bandages.
- Patch the other eye to reduce eye movements. (Remember that when one eye moves, the other eye also moves.)

## OTHER INJURIES.

Injury to the eyes can be a result of overexposure to sunlight. This exposure may cause the patient great pain. An appropriate treatment for this condition is to patch both of the patient's eyes with a material that will prevent further light from reaching them.

It is important to take care of the eyes of an unconscious patient. If the patient is unconscious with the eyes open, the corneas may dry out. Ulcers that can lead to blindness may form. To maintain the natural moisture of the eyes, close the eyelids, cover them with gauze, and tape them shut, making certain that the tape is not touching the globe. If the patient is wearing contact lenses, remove them before proceeding with the treatment.

## OTHER MEDICAL EMERGENCIES INVOLVING THE EYE.

One of the rarest medical emergencies involving the eye, but also one of the most urgent, is central retinal artery occlusion, a condition caused by a blood clot lodging in the main artery of the retina. If not treated immediately, central retinal artery occlusion will lead inevitably to blindness; and even with treatment, the prognosis is poor.

The patient with this disorder will complain of a sudden, painless loss of vision in one eye. It is important to determine when the blindness first occurred, for after more than about 6 hours it is unlikely that the patient's vision will ever be restored. Upon examination, the patient will be found either to have light perception or to be completely blind in the affected eye. The pupil of that eye will be dilated and unreactive to direct light. It will react only consensually; that is, it will constrict when light is shone in the other, healthy pupil. Notify the hospital as soon as the diagnosis is suspected. Massaging the stricken eye may prove effective. Apply, with the heel of the hand, as much pressure as would be necessary to dent a tennis ball. You are trying to dislodge the clot from its central location to a more peripheral point. Since pressure on the eyes causes marked stimulation of the vagus nerve, which decreases heart rate, the heart rate and rhythm should be carefully monitored during the massage. The massage must be stopped immediately if the pulse rate sinks to abnormally low levels.

Otherwise, the massage should be continued for an hour. Transport must be very slow, and care must be taken to avoid sudden jars or bumps.

In virtually all other medical emergencies involving the eye, the affected eye should be patched and the patient taken to the hospital. While many of these conditions represent critical emergencies, little can be accomplished in the field beyond safeguarding the eye from further irritation. Such emergencies include:

- Eye infections—The patient may complain of pain or discomfort. The eye is red and may discharge pus.
- Acute glaucoma—The patient complains of eye ache, headache, nausea, and seeing haloes around lights. The eye is red. The pupil is in midposition and is nonreactive; the cornea, hazy.
- Retinal detachment—The patient experiences light flashes or dark spots in front of the eyes and complains of something blocking the field of vision. In this situation, gentle transport is crucial. The patient should be placed supine on the stretcher and every effort made to avoid bumps, bounces, or sudden stops.

Understandably, any patient with injury or medical problems involving the eye will be anxious and upset. It is important that a calm, reassuring attitude is maintained in dealing with such patients, who naturally fear the loss of sight.

## Emergencies Involving the Face, Ear, Nose, and Throat

Emergencies concerning the face, ear, nose, or throat will generally involve such injuries as fractures, dislocations, or lacerations or such situations as foreign objects impaled in the face or throat or wedged in the nose or ear. Although treatment occasionally varies among different age groups, emergency measures usually center on establishing and maintaining an airway and controlling hemorrhage.

### INJURIES TO THE FACE.

Facial injuries may appear to be dramatic because of concomitant disfigurement and bleeding, but they are of concern primarily because they may be associated with airway obstruction. First, a primary survey should be conducted, and then, as always, hemorrhage should be controlled. Any facial wounds should be covered with sterile dressings. Aspiration of blood may accompany facial hemorrhage; thus, it is important to keep the airway clear. The secondary survey can be conducted after an airway is assured and wounds are dressed.

Two situations in which impaled foreign objects should be removed are when the object is impaled in the cheek and when the object is impaled in the airway and actually obstructs breathing. When the object is impaled in the cheek, gently palpate the inside of the cheek to determine whether the impaled object has penetrated it. Should this be the case, remove the object by carefully pulling it from the side that it entered. If this proves difficult, cease all efforts at removal and immobilize the impalement with bandages. If you succeed at removing the object, pack the inside of the cheek (between the teeth and the cheek) with sterile gauze and a pressure dressing and apply a bandage over the outside of the wound. If bleeding is profuse, position the patient so that blood will drain out the mouth and not into the throat. If warranted, use a suction device to remove the blood.

### TRAUMA TO THE MOUTH AND JAW.

A patient who sustains significant trauma to the face may have a fractured jaw and damaged or lost teeth. Examine the entire face and mouth carefully to ascertain the extent of injury. When the mandible (lower jaw) is fractured, it is likely to be broken in at least two places and will show instability on palpation. If mandibular fracture is suspected, ask the patient to bite down. The patient suffering mandibular fracture will complain of pain and an uneven bite. Ecchymosis and edema may be present as well.

Fracture of the maxilla (upper jaw) is often accompanied by a "black eye." The face appears elongated, and the patient's bite no longer even. Edema is also noticeable. Remember that serious trauma to the face is likely to be associated with cervical spine injury, and extreme care must be taken in these patients to avoid aggravating their condition.

In the field, treatment should be directed at assuring an airway and trying to promote the best possible cosmetic and dental outcome. The following guidelines are recommended:

- Establish an airway. An S-tube can be used if the patient is not conscious. Inspect the mouth for small fragments of teeth or dentures. These fragments can be aspirated by the patient and should be removed promptly. Any blood from the mouth or throat should be suctioned off. Airway obstruction can be a particular problem in maxillary fractures.

- Examine the mouth for broken or missing teeth. If a tooth has been avulsed, try to find it. If you do so, wrap the tooth in a sterile gauze pad soaked in sterile saline and take it to the hospital with the patient. If not too much time has elapsed since the patient lost the tooth, an oral surgeon may be able to reattach it. If an avulsed tooth cannot be found, assume that it has been aspirated.
- Take dentures or pieces of dentures to the hospital with the patient. Dentures are needed to establish proper alignment in wiring a fractured jaw.
- To hold a fractured mandible stable in transport, apply elastic gauze wraps. Make sure that the dressing does not compromise the airway. If the dressing goes underneath the chin, keep a pair of scissors handy to release the dressing should vomiting occur.

## SHOTGUN WOUNDS TO THE FACE.

Shotgun wounds to the face present severe management problems. Occasionally, a patient attempts to commit suicide by putting a shotgun underneath the chin and pointing it toward the head. The length of most shotgun barrels prevents the placement of the fingers on the trigger without hyperextending the neck. In this position, the missiles are aimed toward the eyes rather than the brain. When the shotgun is discharged, the shot and wadding enter beneath the chin, pass through the face between the eyes, and exit through the forehead. Thus, the mandible and the front of the face are essentially bisected. It is in this condition that the patient is usually found—bleeding and with an airway problem, but still very much alive.

Airway obstruction and hemorrhage are the primary problems to be managed. In general, when the patient is first discovered, secure the airway with the immediate application of an endotracheal tube. Establishing an airway by any other means will be difficult because of the extensive structural damage. Good suction, of course, is necessary for placement. Since visualization of the cords may be difficult, the tracheal opening can be located by watching for air bubbles.

After the endotracheal tube is in place, pack 4- by 4-inch gauze into all the open areas around the wound and the endotracheal tube. Then wrap the wound with elastic gauze. This type of direct pressure is usually effective in controlling blood loss.

## TEMPOROMANDIBULAR JOINT DISLOCATION.

Dislocation of the mandible is one of the most disconcerting of injuries. It most often is sustained while eating something of an unusually large size or yawning. Patients who have suffered a dislocated mandible have reported hearing a sudden popping noise and then being unable to close their mouths. As with any dislocation, muscular spasm rapidly develops, and pain can be severe. Immediate reduction is necessary because as time passes and the muscle spasms increase, reduction becomes more difficult. Wrap your thumbs in gauze to protect them and place them in the patient's mouth, one on each side on the lower molars. The fingers should grasp the lower mandible near the angle of the jaw. Place gentle but firm downward pressure to open the joint and stretch the muscles; the force should then be directed toward the back of the head to move the joint back into its normal position (see Fig. 8.12). Be careful; the jaw may snap shut as the dislocation is reduced. Do not exert undue force. If the dislocation cannot be reduced with moderate pressure, sedation or general anesthesia may be required to accomplish reduction, and the patient should be taken to the hospital.

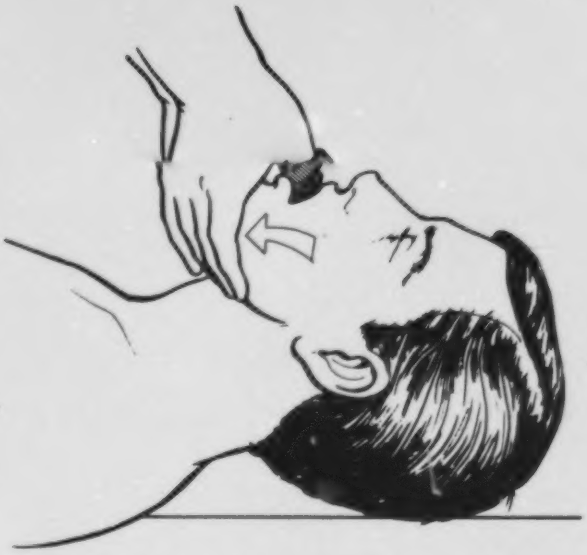

**Figure 12. How to Relocate a Temporomandibular Joint**

## EMERGENCIES INVOLVING THE EAR.

Foreign bodies in the external ear are a common problem among children. The situation usually involves small objects such as beans and peanuts. In general, the treatment in the field is to leave the ear alone and transport the patient to the hospital where good illumination and appropriate equipment are available. The one possible exception to this rule is the situation in which the object in the ear is hygroscopic (absorbs water), such as a corn kernel, bean, or pea, and will thus rapidly swell within the ear canal. If the distance to the hospital is great, the object should be flushed out before transport. To flush an object from the ear:

- Fill a 50-milliliter syringe or bulb syringe with alcohol.
- Have the patient lie down with the affected ear over a basin.

- Place the tip of the syringe near the top part of the entrance to the ear canal. Rapidly but gently flush the ear with alcohol (forceful syringing will drive the object deeper into the canal).
- Transport the patient to the hospital if the object cannot be flushed out easily.

Bleeding or escape of cerebrospinal fluid from the ear has been discussed in Module VII. Field treatment is simply to cover the ear with a dry sterile dressing. Never attempt to stop the flow of cerebrospinal fluid.

## EMERGENCIES INVOLVING THE NOSE.

Epistaxis (nosebleed) is very common. Simple unilateral epistaxis (from one nostril) in young adults and children usually arises from the anterior part of the nose and is secondary to local trauma or acute infection. This condition is best controlled by manual external compression. Such bleeding is rarely heavy, unless it is associated with a fracture, and tends to be self-limited. There is rarely any need to insert an anterior nasal pack while in the field, as compression accomplishes the same purpose—sometimes more effectively.

Severe epistaxis is encountered more frequently among the elderly, especially if there is associated hypertension. The bleeding is often posterior, with no bleeding visible through the nares (nostrils). Inspection of the back of the throat will usually reveal blood dripping down the posterior oropharynx. A severe posterior nosebleed can be a life-threatening emergency, and the patient should be treated initially as any other patient with exsanguinating hemorrhage. (Apply direct pressure and administer an I.V. of crystalloid solution). If signs of shock are present, keep the patient supine, with the head turned to the side to promote drainage of blood. If vital signs are stable, keep the patient in an upright position, head bent over a bowl with the mouth propped open by an airway or bite block. Instruct the patient to breathe entirely through the mouth and to resist the impulse to swallow.

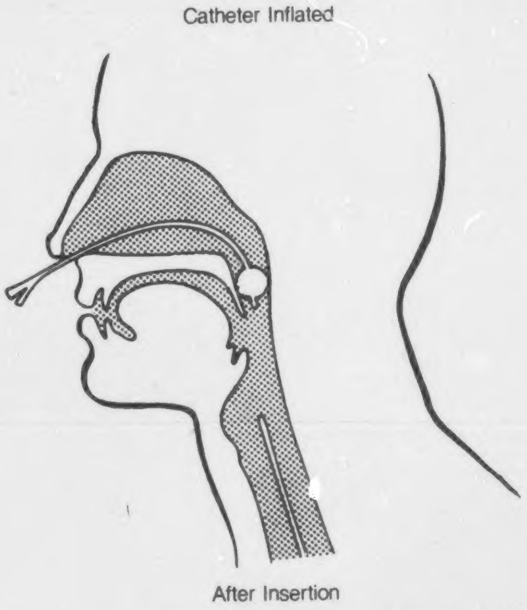

Figure 13. How to Use Foley Catheter for Severe Epistaxis

If this maneuver fails to slow the bleeding, a posterior and an anterior nasal pack should be inserted. The posterior pack will support the anterior pack. In the field, this maneuver is most easily accomplished by passing a Foley catheter with a 30-milliliter balloon into the posterior nasopharynx. The tip distal to the balloon should be cut off to prevent continued stimulation of the posterior pharynx and consequent gagging. The catheter should be lubricated with a water-soluble jelly and passed into the more open nostril until its tip is visible in the back of the throat. The balloon should then be inflated about 15 milliliters and the catheter gently pulled forward until resistance is met. At this point, the balloon should be inflated another 5 to 7 milliliters (see Fig. 8.13). While the Foley catheter is held under traction, the bleeding nostril should be packed anteriorly. The balloon of the catheter will provide a solide posterior wall against which the anterior packing can be applied. The external nares should then be padded with a folded 4- by 4-inch gauze square, and a plastic (umbilical) clamp should be placed across the catheter to secure it against the nares and to maintain tension (see Fig. 8.14). Merely taping the catheter to the cheek is insufficient. Tension should be adjusted so that the balloon is snug but not uncomfortable.

It is not uncommon for children to put small objects into their noses. Basic field treatment consists of leav-

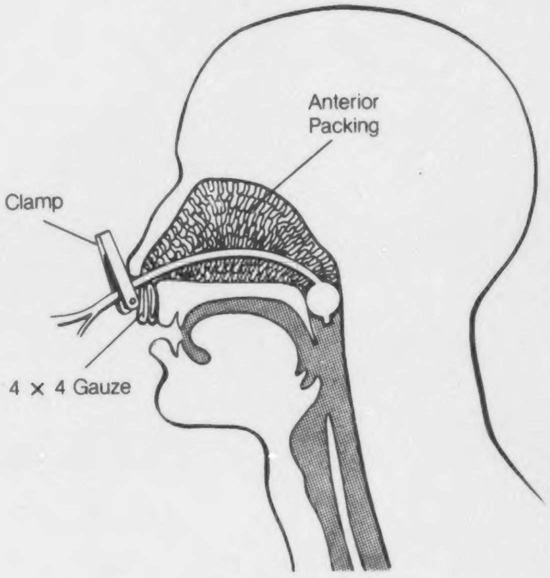

Figure 14. Clamping the Catheter and Applying Traction for the Epistaxis

ing the nose alone. Proper removal of the foreign body requires special equipment and good lighting. The child should be taken to the hospital for treatment.

Nasal fracture (broken nose) can usually be identified by edema and deformity. The only treatment feasible in the field is application of ice compresses in an attempt to minimize the swelling.

## Trauma to the Neck

Soft-tissue injuries involving the neck must be considered critical until proven otherwise. The neck is a very vulnerable part of the anatomy, as it contains the airway, the major blood vessels to and from the head, and the spinal cord. Injury to any, or several, of these structures can be disastrous.

Blunt injury to the neck, signaled by pain, swelling, and ecchymosis, may cause collapse of the larynx or trachea with consequent airway obstruction. Therefore, check these patients immediately to make sure that air exchange is unhindered. Remember that any accident serious enough to cause blunt—or sharp—trauma to the neck may also produce cervical spine injury. Keeping this in mind, immobilize the patient. Any unnecessary movement of the neck should be prevented until spinal injury is ruled out.

If breathing is impaired, assisted ventilation with 100-percent oxygen will be required. If intubation is possible without undue movement to the cervical spine, proceed with a cuffed endotracheal tube. Inline traction can allow insertion of an endrotracheal tube. If you are short handed in the field, you might need to use another type of airway, such as the esophageal obturator. If the cords can be easily seen without a great struggle, the patient should be intubated. If, however, visualization of the cords and intubation will hyperextension of the cervical spine, the patient should be ventilated with a bag-valve mask or Elder valve mask and transported to the hospital without delay. The patient should be observed closely for gastric distention and possible regurgitation with the use of a demand valve ventilatory device.

In penetrating injuries to the neck, disruption of the trachea is characterized by the presence of subcutaneous emphysema in its cervical region and in the anterior chest wall, as well as a frothy mixture of air and blood flowing through the penetrating wound. Seal off such wounds and try to intubate the trachea from above. Place the cuff below the area of the trachea that has been penetrated. If the opening is large enough, the trachea can be intubated through the wound.

Open injuries in the neck carry a hazard of exsanguinating hemorrhage from the jugular veins, carotid arteries, or their branches. Of particular danger is the possibility of air embolism, which occurs when air is sucked into and travels through the veins when intrathoracic pressure is low. Air embolism to the heart can cause arrhythmias (irregular heartbeat) and death.

When there is significant bleeding from the neck:

- Apply a bulky dressing such as a composite pad.
- Maintain manual pressure on the dressing.
- Position the patient on the left side in about 15° of Trendelenburg position (head down, feet elevated).
- Treat for shock (see Module III) if bleeding is profuse or signs of impending shock are present.
- Pack the wound, if it is unusually large, with 4- by 4-inch gauze.
- Transport the patient to the hospital as quickly as possible.

When treating bleeding neck wounds, never probe open wounds or use circumferential bandages to hold dressings in place. Circumferential bandages can interfere with blood flow on the uninjured side of the neck and also impair respiration.

## Injuries to the Abdomen

Abdominal injuries are classified as those that arise secondary to penetrating energy absorption or to blunt injury. Injuries sustained by the solid, hollow, or vascular organs within the abdomen generally cause leakage of their contents into the peritoneal cavity. The makeup of these contents can affect significantly the symptomology and the clinical condition that the patient ultimately develops.

### SOLID ORGANS.

Abdominal trauma may cause the liver, spleen, and pancreas to bleed. The spleen will bleed more than the liver; the pancreas will not bleed as severely, but it will leak digestive exocrine enzymes and produce local irritation and inflammation. Therefore, a moderately rapid influx of fluid into this area associated with the blood loss may result in hypovolemic shock as the blood accumulates. A bluish discoloration may be noted in the flanks or the umbilicus. This sign may not occur for from 6 to 48 hours following the injury. A similar clinical pattern can develop in acute pancreatitis.

In general, blunt or penetrating kidney (renal) injuries rarely bleed enough to cause shock in the prehospital phase, since the kidney is protected by its retroperitoneal position and the fat that surrounds it. If deceleration is severe or a penetrating object is in a medial position (toward the midline), the vascular structures can be injured; and significant blood loss can occur. Signs of trauma (e.g., contusion, laceration, or penetration) in the area of the kidneys accompany this condition.

### HOLLOW VISCUS ORGANS.

Hollow viscus organs can be divided into three categories according to the fluid they contain and the symptoms they produce when injured:

- The stomach contains highly concentrated hydrochloric acid. When acid is emptied into the peritoneal cavity, it causes an almost instant pain, abdominal guarding (tensing), and a boardlike abdomen with associated absence of bowel sounds. The patient frequently can identify the exact time of occurrence. The same symptoms are present both in abdominal trauma and in the acute perforation of a peptic ulcer.
- The contents of the small intestine are much less toxic and require up to 24 hours to cause bacteriological inflammation serious enough to produce peritoneal signs and symptoms. The patient with small intestine (bowel) injury, due to either penetrating or blunt trauma, initially may present no findings except the external evidence of such an injury. It is only after a period of observation that these injuries can be determined. Findings of small bowel injury include gradually diminishing bowel sounds, increasing tenderness, muscular guarding, loss of appetite (anorexia), or vomiting.
- The contents of the large intestine (colon) have a higher bacterial concentration than those of the small intestine; and, thus, injuries to the colon produce symptoms faster than small bowel injuries. The signs and symptoms of trauma to the colon may require as long as 3 to 6 hours to become fully apparent.

### VASCULAR INJURIES.

Vascular injuries present themselves usually in three ways:

- Rapid bleeding leading to an excessive loss of blood (exsanguination) if not promptly controlled.
- Injury to the vessel with rapid blood loss into the abdominal cavity. After 1,000 to 2,500 cubic centimeters of blood are lost, increasing abdominal pressure compresses the vessel and produces hemorrhage control. This control usually lasts until the abdomen is opened, at which time bleeding promptly recurs.
- Mild to moderate blood loss in the retroperitoneal space. In the upper abdomen, bleeding may be from the aorta or vena cava or the iliac vessels in the lower abdomen. Retroperitoneal blood loss from pelvic fractures may be severe.

### MANAGEMENT OF ABDOMINAL TRAUMA.

Patient management should begin with airway establishment, followed by oxygen administration and a primary survey. Specific trauma management consists of appropriate evaluation of the condition, stabilization, volume replacement, and hemostasis. Initial volume replacement and hemostasis can be accomplished with the use of the MAST. The MAST accomplishes a dual function:

- It increases abdominal pressure, serving to reduce blood loss whether due to penetrating trauma, ruptured spleen, or pelvic fractures. It is generally the most effective splint to employ when confronted with pelvic fractures.
- It mobilizes fluid from the lower extremities to the central circulation.

Fluid replacement is used to counteract blood volume loss and to maintain vital signs. There is evidence that overreplacement of blood volume significantly increases the possibility of adult respiratory distress syndrome. Discussion continues as to whether crystalloid or colloid solutions best benefit the patient and produce the least amount of pulmonary difficulty. Therefore, it is important that you continue to review current literature to identify new research and information.

Eviscerations are treated by covering the lesions with moist saline packs; bandaging moderately tight, but not enough to compromise circulation; and transporting the patient to the hospital. Other penetrating injuries should be treated with sterile dressings.

Posterior and anterior evaluations of the abdominal wall should include examination of penetrating injuries and entrance and exit wounds.

## Glossary

**abrasion:** An injury consisting of the loss of a partial thickness of skin from rubbing or scraping on a hard or rough surface; also called brush burn or friction burn.

**air embolism:** The presence of air bubbles in the heart or blood vessels, usually caused by a wound to one of the large veins of the neck.

**antidote:** A substance used to counteract the effects of a drug or to combat the effects of a poison.

**avulsion:** An injury that leaves a piece of the skin or other tissue either partially or completely torn away from the body.

**conjunctiva:** (plural conjunctivae) The delicate membrane that lines the eyelids and covers the exposed surface of the eyelids.

**contusion:** A bruise; an injury that causes a hemorrhage into or beneath the skin but does not break the skin.

**cornea:** The transparent structure covering the pupil.

**cyanosis:** Blueness of the skin due to insufficient oxygen in the blood.

**dermis:** The inner layer of the skin, containing the skin appendages, hair follicle roots, and blood vessels.

**ecchymosis:** The outermost layer of the skin.

**epistaxis:** A nosebleed.

**evisceration:** Protrusion of the viscera through an opening or wound.

**first-degree burn:** A burn affecting only the outer skin layers.

**hematoma:** A localized collection of blood in an organ or tissue as a result of a broken blood vessel.

**hemostasis:** Arrest of bleeding or of circulation.

**homeostasis:** A tendency to constancy or stability in the body's internal environment.

**hygroscopic:** Tending to absorb water.

**impaled object:** An object that has caused a puncture wound and remains imbedded in the wound.

**iris:** The colored portion of the eye that surrounds the pupil.

**laceration:** A wound made by tearing or cutting the tissues.

**mandible:** The lower jawbone.

**maxilla:** The upper jawbone.

**melanin:** The pigment that gives skin its color.

**mottled:** Characterized by a patchy, discolored appearance.

**musculature:** The muscular system of the body, or a part of it.

**orbits:** The bony pyramid-shaped cavities of the skull that hold the eyeballs.

**pallor:** Paleness of the skin.

**puncture wound:** A wound caused by the penetration of the skin with a sharp or pointed object.

**sclera:** (plural sclerae) The white, opaque portion of the eyeball.

**sebaceous glands:** The glands in the dermis that secrete sebum.

**second-degree burn:** A burn that penetrates beneath the superficial skin layers producing the edema and blistering.

**subcutaneous emphysema:** A condition in which trauma to the lung or airway results in the escape of air into the tissues, especially the chest wall, neck, and face, causing a crackling sensation on palpation of the skin.

**sweat glands:** The glands in the dermis that secrete water and electrolytes through the skin.

**temporomandibular joint:** The articulation of the mandible with the skull.

**third-degree burn:** A full-thickness burn, involving all layers of the skin and underlying tissue.

**tourniquet:** A constrictive device used on the extremities to impede venous blood flow to the heart or to obstruct arterial blood flow to the injured extremity.

**vasoconstriction:** Narrowing of the diameter of a blood vessel.

**vasodilation:** Widening of the diameter of a blood vessel.

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## Module IX.

# Musculoskeletal System

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## Module IX.

# MUSCULOSKELETAL SYSTEM

## Introduction

The musculoskeletal system is a complex, highly organized group of structures that provides protection, shape, support, and locomotion for the human body. A variety of components, including bones, muscles, ligaments, tendons, and cartilage, make up the muscu-

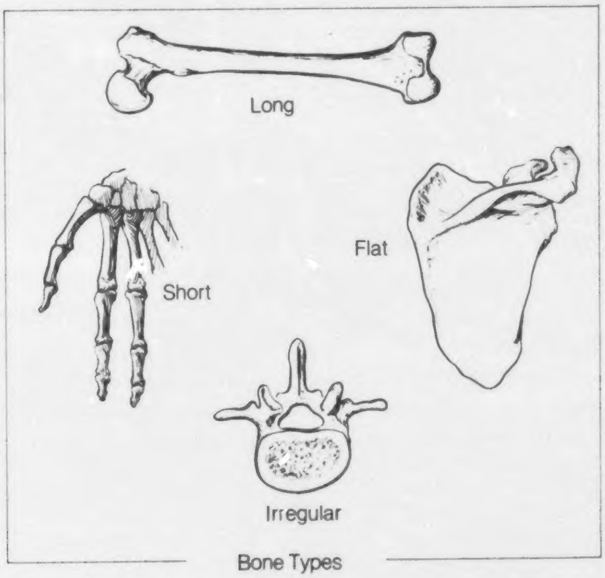
Long
Short
Flat
Irregular
Bone Types

**Figure 1. Long, Short, Flat, and Irregular Bones**

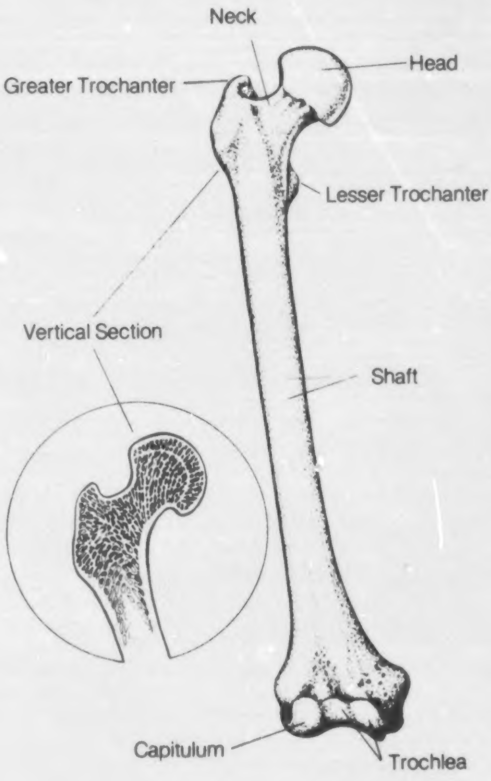
Neck
Head
Greater Trochanter
Lesser Trochanter
Vertical Section
Shaft
Capitulum
Trochlea

**Figure 2. Femur**

loskeletal system. When the body is exposed to external trauma, such as a motor vehicle accident, one or more of these components are frequently damaged. In order to recognize and properly treat an injury, it is necessary to understand the composition and organization of the system. To help facilitate this understanding, each of the major components will be considered separately.

## Unit 1. Anatomy and Physiology

### Skeletal System

The human skeleton is composed of 206 bones of many shapes and sizes. They are classified according to their shapes: Long bones, such as the humerus (bone of the upper arm); short bones, such as the phalanges (finger and toe bones); flat bones, such as the sternum (the breast bone); and irregular bones, such as the vertebrae (see Fig. 9.1).

Each bone has its own characteristic structure. With some variation, the illustration of the femur (see Fig. 9.2) shows the major components of a long bone.

The bone's outermost layer is a fibrous membrane called the periosteum, which allows for new bone formation. The next layer is called the cortical bone; it is dense and hard, providing much of the strength of the bone. Next comes the cancellous portion, which is soft and spongy. The hollow central portion, the medullary canal, contains the bone marrow, which is responsible for the formation of the blood. The ends of the bone (where it comes together with other bones to form a joint) are covered with a very dense smooth material—articular cartilage—that helps cushion the bone ends and provides a smooth surface to allow for relatively frictionless motion. The diaphysis is the middle portion, or the shaft, and the metaphysis is the end portion of the bone.

### Skull

The skull furnishes a strong, durable case to protect the brain (see Fig. 9.3). Composed of 22 bones, the skull also provides the chewing mechanism and a framework for the facial structure.

The cranium—the frontal, temporal, parietal, and occipital bones—provides the protective case for the brain and, with the facial bones, supports the ears, eyes, and nose. The maxilla is the upper jaw. The mandible, or lower jaw, is attached to the skull by a hinge joint that makes chewing possible. The skull is attached to the spinal column, which is composed of the 33 bones known as vertebrae. The spinal column has two major functions: First, it supports the head and neck; second, it protects the spinal cord, which is the major pathway for information passing between the brain and the rest of the body (see Fig. 9.4).

Each vertebra is separated by a cartilaginous disk that cushions the system and allows only limited movement, protecting the spinal cord when motion occurs (see Fig. 9.5).

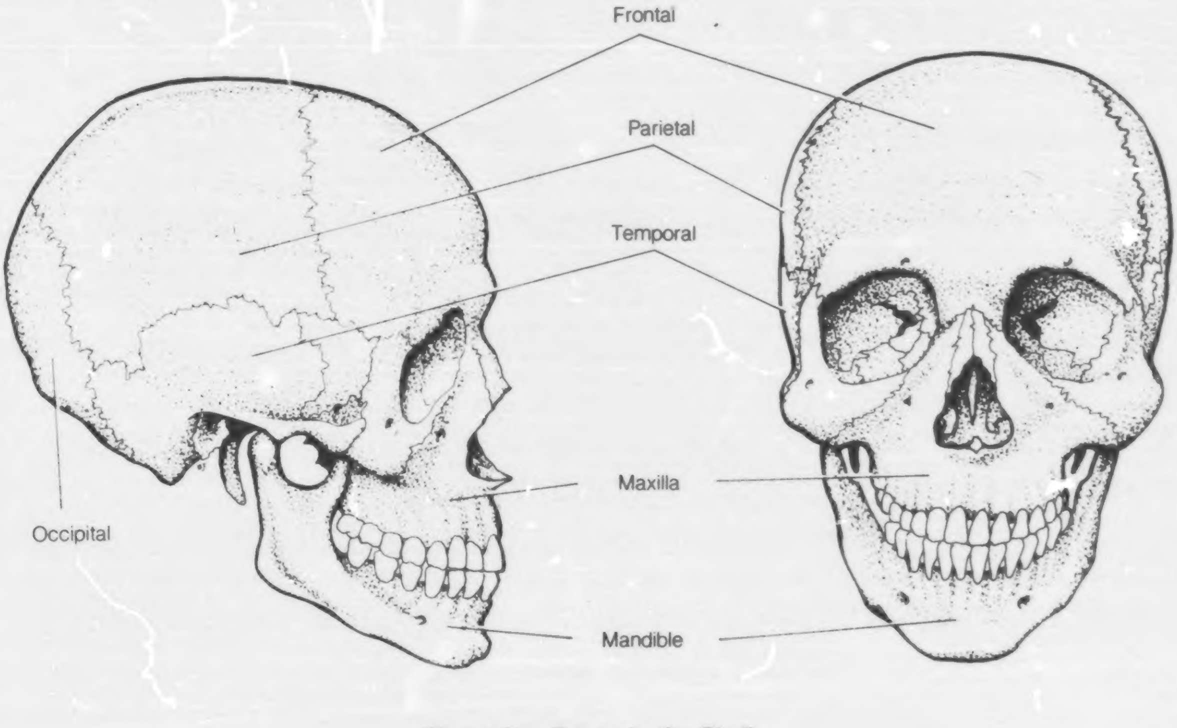

**Figure 3. Bones in the Skull**

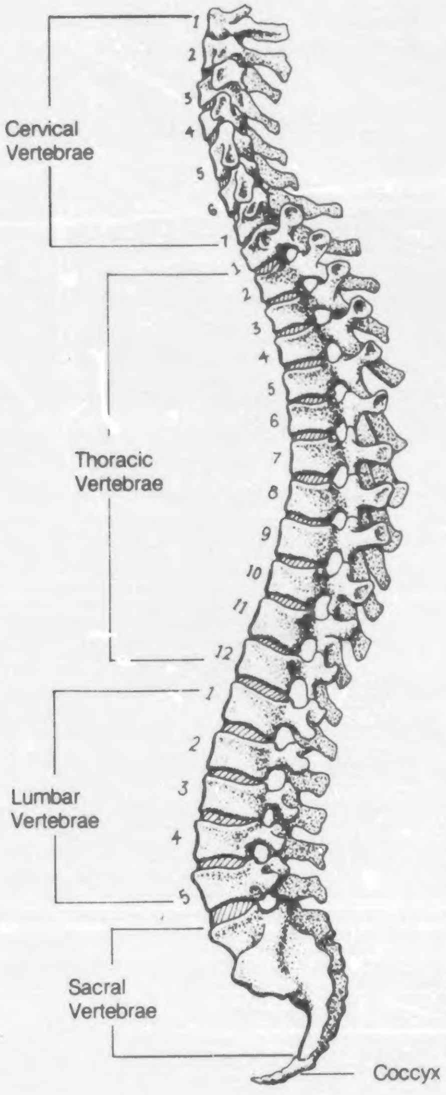
Cervical Vertebrae
1
2
3
4
5
6
7
Thoracic Vertebrae
1
2
3
4
5
6
7
8
9
10
11
12
Lumbar Vertebrae
1
2
3
4
5
Sacral Vertebrae
Coccyx

**Figure 4. Spinal Column**

## Vertebrae

The spinal column is made up of 5 regions: The cervical spine, with 7 vertebrae; the thoracic, with 12; the lumbar, with 5; the sacral, with 5 fused vertebrae, which is fused to the 4 fused vertebrae of the coccyx. It is easy to see, looking at Figure 9.4, how a fracture or a dislocation of the spine can injure the spinal cord. The cervical and lumbar areas are the most commonly injured, because they have much less support than the other areas of the spinal column. There is low incidence of thoracic- and sacral-spine injuries because of the protection afforded by the ribs and pelvis, respectively.

## Thorax

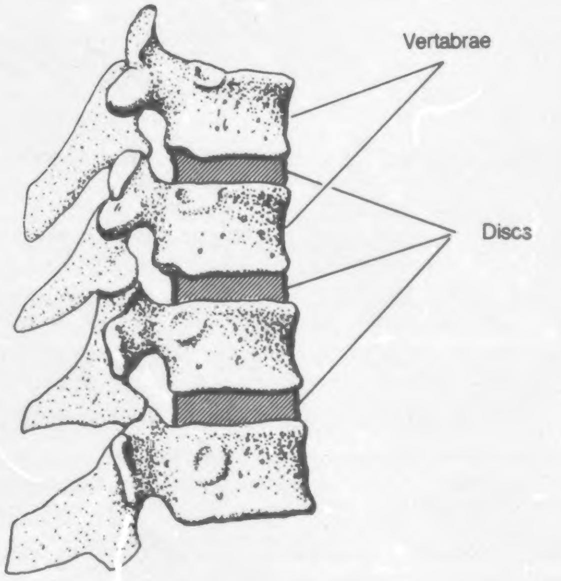
Vertabrae
Discs

**Figure 5. Cartilaginous Disks Separating Spinal Vertebrae**

The thorax is composed of 12 pairs of ribs, the thoracic spine, and the sternum (breastbone). The ribs protect the intrathoracic organs, such as the heart, the great vessels, and the lungs, and, with the help of their attached muscles, provide for the motion that is critical to respiration (see Fig. 9.6). The first 10 pairs of ribs are attached to the sternum by a common piece of cartilage; the last two are not attached and are called floating ribs. Above the thorax is a set of bones, known as the shoulder girdle, that ring the thorax and help to form the shoulder joints. The clavicles (or collarbones) form the front of the shoulder; the scapulae (shoulder blades), the back.

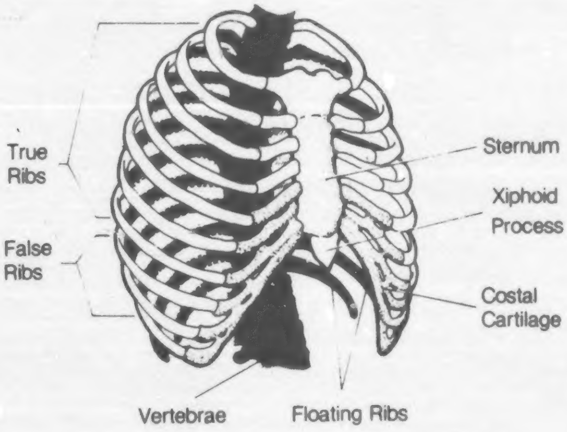
True Ribs
False Ribs
Sternum
Xiphoid Process
Costal Cartilage
Vertebrae
Floating Ribs

**Figure 6. Bones Comprising the Thorax**

## Extremity

The humerus (upper arm) has at its upper end a rounded surface that fits into a socket in the scapula to form the shoulder joint and at its lower end an-

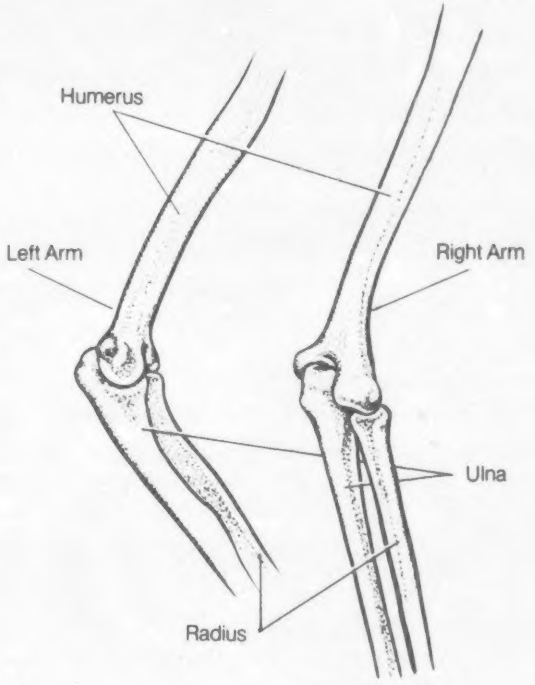
Humerus
Left Arm
Right Arm
Ulna
Radius

**Figure 7. Bones Comprising the Elbow**

other rounded surface that joins with the radius and ulna (forearm) to form a hinge joint (elbow) (see Fig. 9.7). The radius and ulna, in turn, join with the carpal bones to form the wrist, which is linked to the metacarpal bones—the bones in the hand between wrist and fingers which end in the knuckles. The fingers are composed of three bones (the thumb has two) called phalanges that form hinge joints that allow the fingers to bend.

## Pelvis

The pelvis consists of six bones in addition to the sacrum and the coccyx that, like the shoulder girdle, forms a ring (see Fig. 9.8). The wide broad ilium joins on each side with the sacrum and the sacroiliac joint. The bones are joined in the front at the symphysis pubis. Although the pelvis has three bones on each side, they are actually fused into one. Together they form a socket into which the ball-shaped head of the femur fits to form the hip joint. The pelvis bones support and protect the pelvic organs.

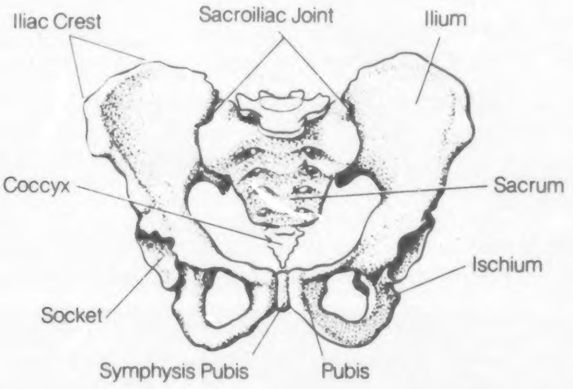
Iliac Crest
Sacroiliac Joint
Ilium
Coccyx
Sacrum
Ischium
Socket
Symphysis Pubis
Pubis

**Figure 8. Bones Comprising the Pelvic Girdle**

## Femur

The bone in the leg closest to the pelvis is the femur. Its upper end is shaped like a ball and fits into the socket of the pelvis. At its distal end, the femur joins with the tibia to form the knee joint. The tibia and fibula are connected to the tarsal bone to make the ankle (see Fig. 9.9).

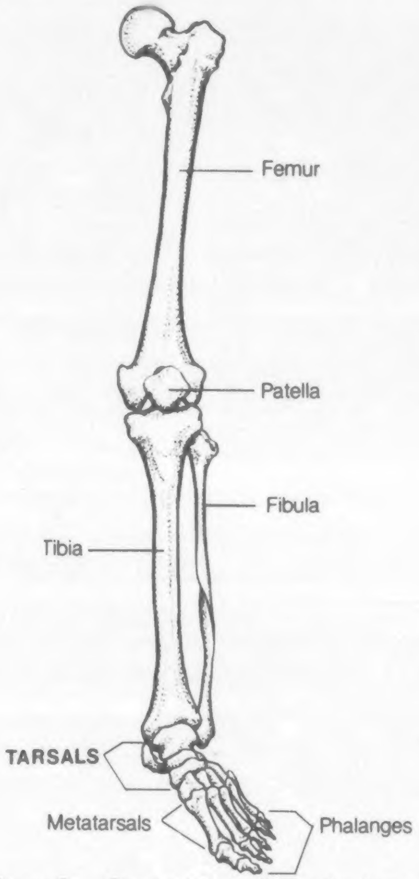
Femur
Patella
Fibula
Tibia
TARSALS
Metatarsals
Phalanges

**Figure 9. Bones Comprising the Lower Extremity**

## Foot

The bones of the foot are the tarsal, metatarsal, and phalangeal bones. Its structure is very similar to the hand's, except that the foot is built for less motion and more stability to accommodate the weight that the legs must carry.

## Joint

A joint is where two bones come together. The joint provides stability but, more important, allows for motion between the two bones. A typical joint is composed of two bone ends covered with articular cartilage that allows movement of the two ends with minimal friction. A thin tissue, the synovial membrane, covers this structure and secretes a fluid that lubricates the joint. The bone ends are held in place by a fibrous membrane called the joint capsule. Firm, strong bands of tissue called ligaments help to hold the bone ends together (see Fig. 9.10).

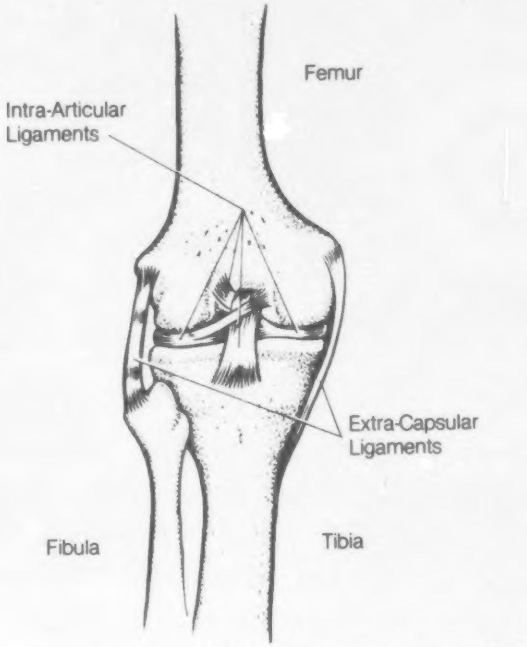

**Figure 10.** **Manner in Which Bones are Connected by Ligaments**

There are joints that allow for very little motion and are very stable, such as the sacroiliac joint (see Fig. 9.8). And there are fused joints that allow no motion at all, like the suture lines in the skull. The brain of a newborn child is not fully grown, so the skull must allow for expansion: The bones have not closed at the suture lines. When the brain reaches full size, the bones grow together to create a closed vault (see Fig. 9.11).

## Muscle

Muscle is a special kind of tissue that has the ability to contract, or shorten. Through contracting and relaxing, muscles provide the force that allows us to walk, that pushes our blood through the blood vessels, and that propels our food through our gastrointestinal tract.

There are three kinds of muscle, each with different functions and characteristics. The most abundant muscle in the body is called voluntary, or skeletal, muscle. These muscles are under our direct control; they include the muscles that open and close the fingers or the mouth. The second type is called involuntary or smooth muscle. These muscles work automatically and are not under our conscious control (e.g., the muscles in the walls of blood vessels that cause them to constrict or dilate, the muscles in our gastrointestinal tract, and the muscles in the bronchi). The third type of muscle is cardiac, which has the ability to rhythmically contract in the absence of any external stimuli. Cardiac muscle is discussed in greater detail in Module VI.

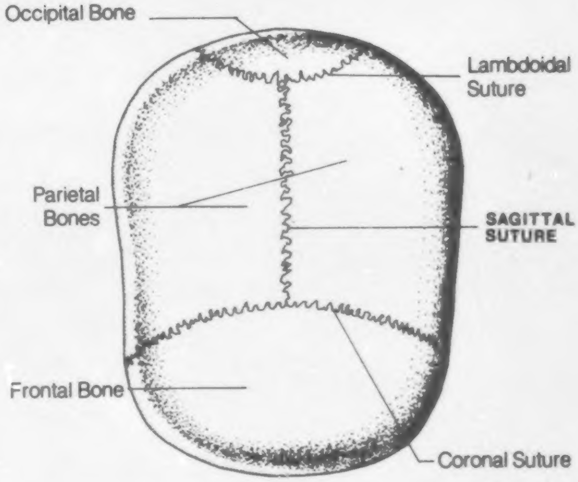

**Figure 11.** **Skull Fused Joints**

Since skeletal muscle makes up the greatest body of muscle tissue and is the most commonly injured, it must be studied closely. A muscle has an origin (where it attaches to a stationary bone) and an insertion (where it is attached by a tendon to a movable bone). The muscle usually crosses a joint so that when it contracts (or shortens), it causes the joint to move. Muscles usually work in pairs: One extends a bone, and the other flexes the same bone. They are in

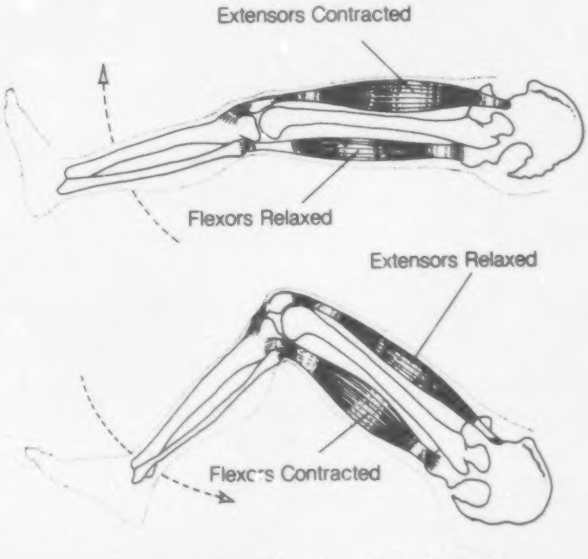

**Figure 12.** **How the Muscles Work in Balance About A Joint**

balance so that at rest a joint will assume a neutral position and then when stimulated one of the pair will contract. This happens, for example, when you extend or flex the knee (see Fig. 9.12).

## Unit 2. Patient Assessment

The evaluation of a patient with possible musculoskeletal damage requires looking over the scene of the accident to determine what caused the injury, obtaining an accurate patient history, and giving a thorough physical examination. Take note of the patient in relation to the environment (possible mechanisms of injury). Ask the patient to identify the areas of pain and to move each extremity. Finally, a patient history should be elicited and a physical examination conducted.

### Mechanisms of Injury

Orthopedic trauma can result in a variety of ways and should be suspected whenever a patient shows certain types of injuries, including:

- Direct injuries—a broken bone at the point of impact with a solid object, such as a dashboard or automobile bumper.
- Indirect injuries—a fracture or a dislocation at some distance along the bone from the point of impact, such as a hip fracture caused by the knees slamming into the dashboard.
- Twisting injuries—fractures, sprains, and dislocations that occur, typically, when there is torsion of the joint while the distal part of the limb remains fixed, as when football cleats or a sticky ski binding keep the foot from moving when it needs to. The resulting forces cause shearing and fractures.
- Powerful muscle contractions—muscle torn from the bone or muscle breaking away a piece of the bone. Occurs in seizures or tetanus.
- Fatigue fractures—caused by repeated stress. These most commonly occur in the feet after prolonged walking ("march fractures").
- Pathologic fractures—occur in patients with diseases like metastatic cancer that weaken areas of bone. They may occur with minimal force. The elderly have more brittle bones and are thus more prone to pathologic fracture.

The paramedic must evaluate the scene to determine which of the above mechanisms of injury was at work.

### Patient History

Most patients with significant musculoskeletal injury will complain of pain. Usually the pain is well localized to the area of injury. Sometimes the patient who has sustained a fracture will report having felt something snap. The paramedic should try to discover how the injury occurred and determine what position the limb was in when it happened. For example, in the case of a twisted ankle, did the injury occur with the ankle bent outward (everted) or bent inward (inverted)? Does the patient have any serious illnesses (e.g., cancer) that might help account for an otherwise unexplained fracture?

### Physical Examination

With rare exceptions, fractures and other orthopedic injuries are not life threatening. In the patient with multiple injuries, fractures may be the most obvious and dramatic, but may not necessarily be the most serious. Therefore, the paramedic should do the primary survey and manage any life-threatening conditions first. Management of orthopedic injuries fit in their appropriate place in the secondary survey.

#### LOOK.

Swelling and a black-and-blue mark (ecchymosis) indicate escape of blood into the tissues (extravasation). This may come from either the bone end or associated muscular and vascular damage. Shortening or angulation between the joints, deformity or angulation in unusual direction around the joints, shortening of the extremity, and internal or external rotation when compared with the opposite extremity indicate a bony defect. Lacerations or even small puncture wounds near the site of the bony fracture are considered open fractures.

#### LISTEN.

Crackling sounds (crepitation) can be heard with the stethoscope or felt with the palpating fingers. They are produced when the broken bone ends rub together. Additional injury can ensue if you listen for the crackling too vigorously. Do not attempt to elicit this sign. Percussion over a bony protuberance while listening with a stethoscope on another bony prominence distal to a fracture will produce a sound different from the sound produced on an uninjured bone.

#### FEEL.

If no obvious fractures exist, three-point fixation of each should be accomplished and gentle pressure applied at the middle point. Pain so produced indicates a stretching of the periosteum. Crepitation indicates broken bones. Palpation along the length of the bone can help detect deformities, bony protuberances, or angulation that is not seen.

Pulse and neurological sensation should always be evaluated distal to the fracture both before and after application of splints. In the arm, you should test the radial and ulnar arteries, and in the leg, the dorsalis pedis and posterior tibial arteries (see Fig. 9.13). If there is no distal pulse, two or three gentle manipulations of the extremity should be carried out to try to restore the blood flow. Do not make prolonged attempts; the loss of blood may be due to actual vascu-

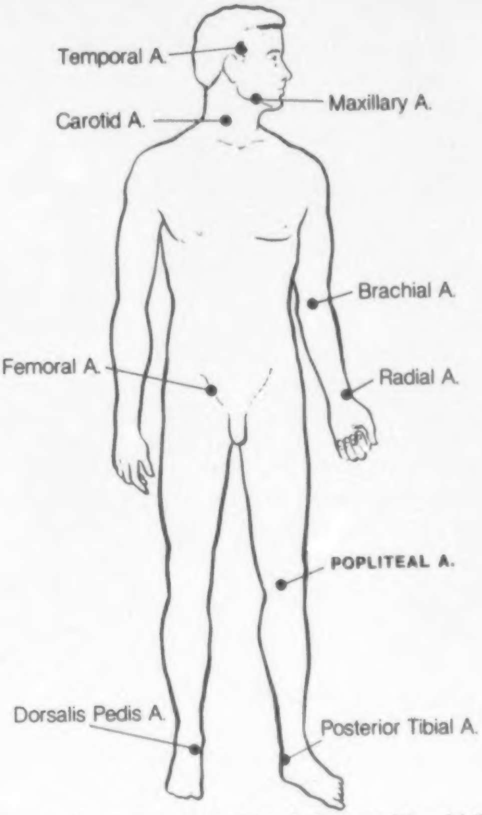

**Figure 13. Where the Distal Pulses Should Be Found**

lar injury or to preexisting hardening of the arteries (arteriosclerosis) rather than simple compressions.

A neurological evaluation of both motor and sensory functions should be made. When checking an arm, for example, make sure that the radial, ulnar, and median nerves are intact and that the hand can demonstrate the continuity of sensory nerves by both cutaneous sensation and finger movements.

When doing the secondary survey, every bone in the body should be palpated and manipulated to determine the injury. The only exception to the manipulation is with possible spinal column injuries. Some bones, such as the ribs and the pelvis, can be palpated by applying direct pressure. As in the case of the pelvis, this means bilateral pressure on the anterior iliac spines and a simultaneous posterior direction to elicit pain. Pressure over the symphysis pubis will also flex the pelvic ring to detect any existing fractures.

It is difficult many times to distinguish between fractures and sprains without roentgenography (X-ray). If there is a question, immobilize and treat the injury as if it were a fracture. In general, the pain produced by a fracture will cause muscular spasm. The patient, therefore, will guard or not move that fractured bone at all. It is not true that a fracture produces paralysis distal to the fracture. Only nerve damage produces paralysis. The pain may be so great, however, that the patient does not voluntarily move the bone or its muscular attachment.

## Unit 3. Pathophysiology and Management of Orthopedic Injuries

Table 9.1 gives the signs and symptoms of common orthopedic injuries—fractures, dislocations, and sprains.

### Fractures

A fracture is a break in the continuity of bone. It may either be closed, in which case the overlying skin is intact, or open, in which case there is a wound over the fracture site. In an open fracture, bone may or may not be protruding through the wound. Open fractures are more serious than closed fractures, because the risks of contamination and infection are greater. The radiographic appearance of the fracture is used to determine both definitive treatment and prognosis.

**Table 9.1**

**Common Orthopedic Injuries: Signs and Symptoms**

| Fracture | Dislocation | Sprain |
|---|---|---|
| Pain, tenderness. | Pain | Pain on movement; tenderness. |
| Deformity or shortening. | Deformity | No deformity. |
| Loss of use | Loss of movement. | Painful movement. |
| Swelling | Swelling | Swelling. |
| Ecchymosis | Ecchymosis | Redness. |
| Grating | Located at joint | |
| Guarding | | |
| Exposed bone ends. | | |

A transverse fracture cuts across the bone at right angles to its long axis and is often caused by direct injury. The greenstick fracture is an incomplete fracture that commonly occurs in children, whose bones (like green sticks) are still pliable. Spiral fractures usually result from twisting injuries, and the fracture line has the appearance of a spring. The fracture line of an oblique fracture crosses the bone at an oblique angle, or in a slanting direction. In impacted fractures, the broken ends of the bone are jammed together and may function as if no fracture were present. A comminuted fracture is one in which the bone is fragmented into more than two pieces (splintered or crushed) (see Fig. 9.14).

Fractures—even open fractures—seldom present an immediate threat to life, and thus their treatment should be deferred until life-threatening conditions

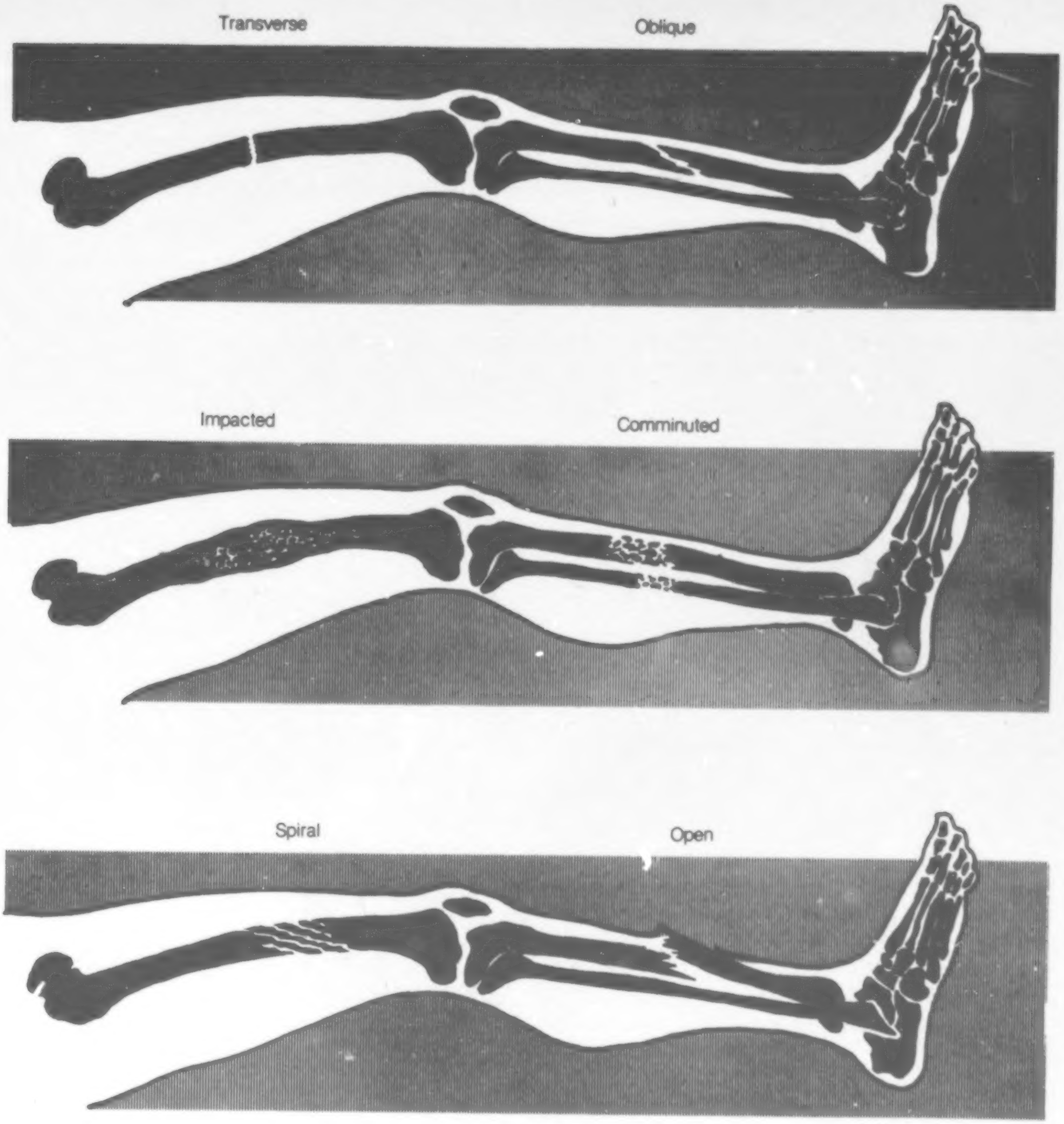

**Figure 14. Transverse Fracture and Other Common Fractures**

have been handled by establishing an airway and by controlling hemorrhage. A tourniquet is practically never necessary in treating an open fracture, even when a limb has been mangled beyond all possibility of salvage, or a traumatic amputation. Only when all life-threatening conditions have been dealt with is it appropriate to identify and immobilize all fractures in preparation for transport.

Immobilization is commonly accomplished by splinting, which is done for the following reasons:

- To prevent a closed fracture from becoming an open one.
- To prevent damage to surrounding nerves, blood vessels, and other tissues by the broken bone ends.
- To lessen bleeding and swelling.
- To diminish pain.

Principles and specific examples of splinting are discussed in Unit 4 of this module. You should:

- If dealing with an open injury, irrigate with copious amounts of normal saline to remove all dirt and debris. Dress the wounds before splinting the fractures.

- Straighten any severely angulated fractures that can be safely straightened. Do not attempt to straighten fractures involving the elbow.
- Do not push back bone ends that may be protruding from an open fracture; they may reduce spontaneously upon traction or splinting. Irrigation should be performed to remove the debris so that none is pulled into the wound.
- Immobilize extremities before moving the patient. This does not mean, however, that it is necessary to apply splints. It may be necessary to either splint the injury for extrication or to extricate using in-line traction, splinting after extrication. In-line traction is applied by holding some portion of the extremity distal to the fracture, applying traction along the long axis with one hand while supporting the extremity beneath the fracture with the other. This will allow the extricator to move the patient or allow the patient to move himself while protecting the fracture from further injury.
- Immobilize the joints above and below a fracture.

Manipulation of a fracture can be a two-person operation. This should be accomplished by one person stabilizing the bony fragment proximal to the injury while the other person applies in-line traction with one hand and with the other hand supports the fracture. The distal fragment is moved in line with the proximal fragments. Muscular attachments and spasms of the proximal fragment frequently make movement difficult. Before movement can be accomplished, it may be necessary to relax the muscle spasm by applying gentle traction, gradually increasing the strength. The position of the proximal fragment can be determined by palpation; but knowledge of the muscle origin, insertions, and their functions can help anticipate its location.

## Dislocations

A dislocation is the displacement of a bone end from its articular surface, accompanied sometimes with tearing of the ligaments that normally hold the bone end in place. The shoulder, elbow, fingers, hips, and ankles are the joints most frequently affected.

The principal symptoms of dislocation are either pain or a feeling of pressure over the involved joint and loss of motion of the joint. The principal sign of dislocation is deformity. If the dislocated bone end is pressing on nerves or blood vessels, there may also be compromise of the corresponding functions—that is, numbness or paralysis below the dislocation. When dealing with a fracture or dislocation, always check the pulses, strength, and sensation distal to the injury. The general principle of treating dislocations is to immobilize the involved part in the position in which it was found. Do not straighten or attempt reduction.

If there is no distal pulse in the involved extremity and if it is not restored by gentle manipulation, transport the patient to the hospital promptly. Gentle manipulation is accomplished by in-line traction and by moving the distal bone fragment in line with the proximal fragment. When reducing a dislocation in the field, keep in mind that severe muscle spasms may be present. Muscle spasms may increase with the passage of time. Therefore, reduction should be accomplished as soon as practicable, making allowances for the patient's other injuries. Because of the difficulty in identifying a fracture above the joint (supracondylar fracture) of the humerus or elbow, no attempts should be made to reduce them. If pulses are absent in an elbow fracture, immobolize the elbow at approximately a 45° angle. Extreme flexicon or extension may further compromise the vascular supply.

When attempting to reduce dislocations, in-line traction should be applied slowly and steadily to relax the muscle spasm. Then the distal bone should be returned to its normal position relative to the proximal bone. The distal bone—and not the proximal bone—should be maneuvered. Tendons or ligaments may become entrapped between the articulating surfaces making closed reduction impossible. If the dislocation cannot be reduced after one or two attempts, transport the patient to the hospital.

## Sprains

Sprains are injuries in which ligaments are partially torn, and usually occur when a joint is suddenly twisted beyond its normal range of motion. Sprains most commonly affect the knees and ankles and are characterized by pain, swelling, and discoloration over the injured joint. Unlike fractures and dislocations, sprains usually do not manifest deformity. It is best, however, to treat the sprain as if it were a fracture and to immobilize it accordingly. The sprained joint should be elevated, and an ice compress, if available, should be applied.

## Strains

Strains are soft-tissue injuries or muscle spasms around a joint and are characterized by pain on active movement. There is no deformity or swelling associated with a strain, and passive movement elicits little, if any, pain. Strains are best treated by avoiding weight-bearing on the injured area. If there is doubt as to the nature of the injury, the extremity may be immobilized pending evaluation in the emergency department.

# Unit 4. Techniques of Management

## General Principles of Splinting and Immobilization

In the management of musculoskeletal injuries, remember the following principles:

- Severely angulated fractures of long bones should be straightened before splinting. Explain to the patient that straightening the fracture may cause momentary pain, but that it will abate significantly once the fracture is straightened and splinted. Any overlying clothing should be cut away.
- Do not straighten dislocations and any fractures involving the spine, shoulder, elbow, wrist, or knee.
- The adage "splint them as they lie" should be changed to "immobilize them where they lie." Splinting may well be accomplished after extrication. If pulses are absent, splinting may necessitate manipulation of the fracture to its normal position.
- In open (compound) fractures, no attempt should be made to push bone ends back beneath the skin surface. They should simply be covered with a sterile dressing.
- The joints should be immobilized above and below the fracture (e.g., at the wrist and elbow for fractures of the radius and ulna).
- Splinting should be done firmly, but not so tightly as to restrain, or occlude, circulation. Distal pulse should be checked after the splint is in place to be certain that the circulation is still adequate. If the pulse disappears, the splint should be loosened until it is again palpable. Air splints should be checked and rechecked to make certain that they are not overinflated. The ankle hitch on the traction splint should be inspected so that it is not applied too tightly across the foot; all areas of contact should be padded. The proximal end of a lower extremity splint should not press against the groin. Board splints should be long enough, well padded, and for stability well secured to the uninjured parts of the body.
- For fractures above the knee or about the hip, a traction splint is best (Thomas half ring or Hare traction). Such fractures can be well managed by supporting the extremity with the hip and knee in slight flexion and the extremity stabilized by strapping it to the uninjured leg. Because inflatable splints do not splint above the joint, they should not be used. However, pneumatic Military Anti-shock Trousers (MAST) can splint both hips and knee joints.
- For massive trauma to the lower extremities, MAST can be used as a splint and will also help achieve hemostasis. (see Module II for MAST application.)
- All fractures should be immobilized before moving the patient.
- Fracture of the tibia or fibula can be managed with traction splints, air splints, or wooden or ladder splints. Whichever kind is used, the knee must also be immobilized. MAST cannot be used for below-the-knee fractures.
- When other methods are not available, the long backboard can be used to manage almost any fracture.
- An upper extremity fracture can usually be managed by immobilization against the chest.
- The fingers and toes should be exposed even though they are included within a splint.

## Types of Splints

Any device used to immobilize a fracture or dislocation is a splint. This device may be improvised, such as a rolled newspaper, cane, ironing board, or virtually any other object that can provide stability; or it may be one of the several commercially available wooden, inflatable, or traction splints. It is with these latter devices that this section is concerned. However, the lack of a commercially made splint should never prevent a paramedic from properly immobilizing an injured patient; multiple casualties may tax the resources of even the best-equipped ambulance, and ingenuity in improvisation will be necessary to render adequate care.

A rigid splint is an inflexible device attached to a limb to maintain stability. It may be simply a padded board, a piece of heavy cardboard, or an aluminum splint molded to fit the extremity. But whatever its construction, it must be long enough to be secured well above and below the fracture site.

To apply a rigid splint, the extremity is grasped above and below the fracture site and gentle traction is applied (see Fig. 9.15). The splint, adequately padded to assure even pressure, is attached to the extremity.

**Figure 15. Maintaining Traction**

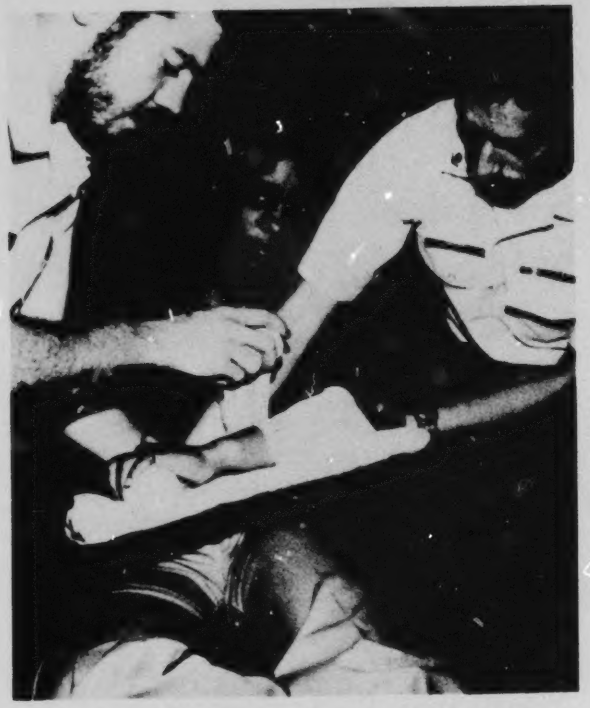

Figure 16. Traction and Splint Wrapping

While one rescuer maintains traction, the other wraps the limb and splint in self-adhering bandages, tight enough to hold the splint firmly to the extremity, but not so tight to occlude the circulation (see Fig. 9.16).

Air splints are useful primarily for immobilizing fractures involving the lower leg or forearm. The technique of applications will depend on whether the air splint is equipped with a zipper. If it is not, the splint should be gathered on your arm so that the bottom edge is just above the wrist. The patient's hand or foot should be grasped while maintaining proximal traction, and the air splint should be slid over the rescuer's hand onto the patient's extremity. The air splint should be positioned free of wrinkles. Then, while continuing to maintain traction, the splint should be inflated by mouth. If the air splint has a zipper, it should be applied to the injured area while the assistant maintains traction proximally and distally, and then it should be zipped up and inflated (see Figs. 9.17 and 9.18). In either instance, the splint should be inflated just to the point when a finger against the splint will make a slight dent.

After applying the pneumatic splint, check the skin color and pulse and ask the patient if the pain has been partially relieved by stabilization of the fracture. Check the skin color and pulse through the transparent splint every 5 minutes to guarantee continued good circulation. Ask the patient if he or she has sensation in the fingers or toes.

The fingers should not protrude beyond the end of the air splint. (If the fingers or toes protrude beyond the end of the air splint, it might act as a tourniquet.)

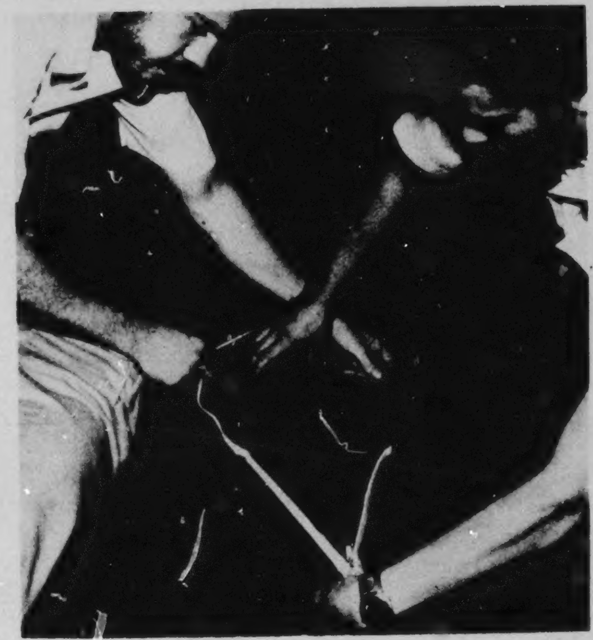

Figure 17. How to Maintain Traction While Applying an Air Splint

Again, it is important to remember that the splint must come above the joint proximal to the fracture. The applied splint that does not immobilize the joints both above and below the fracture acts as a lever arm and can actually worsen the injury. For example, if a splint is applied that does not come above both the elbow and the fractures in the radius and ulna, the rotation and movement of the bone is not stopped. Muscle, nerve, and vascular damage can continue de-

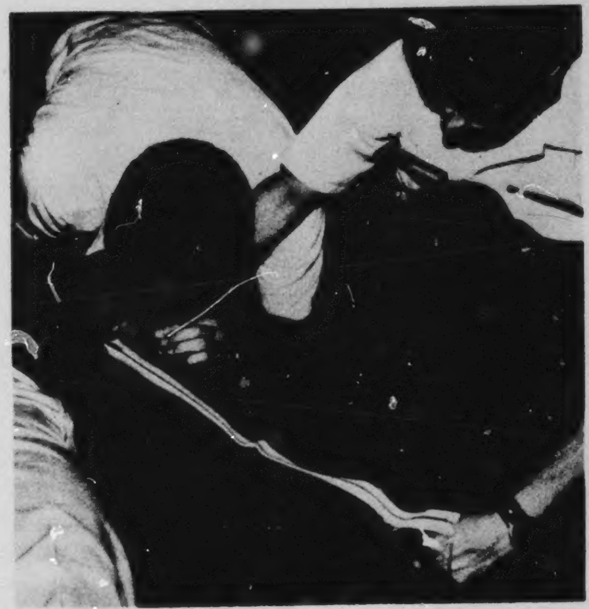

Figure 18. How to Maintain Traction While Inflating Air Splint

spite the splint. This applies to fractures of the lower extremities as well.

If a femoral fracture is involved, the splint must include the hip, which means the use of either the MAST or a traction splint, such as a Hare traction splint or Thomas half ring.

Air splints must be carefully monitored so that they do not lose pressure or become overinflated. Overinflation is particularly a danger when the splint is applied in low temperatures and the patient is subsequently moved to a warmer area, where the air in the splint expands. A hemorrhage into the fracture site can increase splint pressure as well.

## TRACTION SPLINTS.

Traction splints are used to provide constant pull on an extremity, supplying the traction that is always a part of the immobilization of a fracture and preventing broken bone ends from overriding due to muscle contraction. They do not reduce the fracture, but simply immobilize the bone ends and prevent further injury. Traction splints are generally used for fractures of the femur or the hip.

The most commonly used traction splints are the Thomas half ring splint and the Hare traction splint. The basic principles of application are the same for both:

- Traction is applied to the injured leg by grasping the ankle and calf and gently pulling.
- While the first rescuer maintains this traction, the second rescuer slides the splint under the leg and secures the half ring splint in position, pressing firmly against the ischial tuberosity—the rounded projection of the hipbone.
- When the half ring has been fastened, the second rescuer applies and secures the ankle hitch.
- Traction is developed by tightening the winding device, or windlass, until the patient experiences relief of pain.
- The splint is then elevated so that the patient's foot is clear of the ground or the stretcher, and the leg is secured by cravats or Velcro straps at intervals along the splint.
- A Hare traction splint is applied in much the same way as the Thomas half ring splint. But with the Velcro straps between the two longitudinal rods and the traction apparatus at the foot, the application of traction becomes much simpler and much faster.
- Distal pulses, cutaneous sensation, color, and capillary refilling must be checked every 5 to 10 minutes after applying either splint.

Removal of motorcycle helmets in the proper manner is very important. Cervical spine injury can result from neck motion if the helmet is removed in a haphazard manner. Two rescuers are required. The first takes a position by the patient's head placing the palm of each hand on a side of the helmet. The long and ring fingers should overlap the bottom of the helmet and be touching the mandible. In this manner, in-line traction of the cervical spine can be applied without losing head traction. Additional traction can be obtained by pulling on the mandible.

The second rescuer slips one hand beneath the back of the helmet, placing it firmly on the back part of the skull, the occiput, with the thumb and long fingers in contact with the mastoid process (the projection of the temporal bone behind the ear) or the cranium just above the mastoid. The second hand is slipped inside the front of the helmet, the thumb and long finger each touching a side of the mandible. Thus both rescuers apply in-line traction in the same direction.

The rescuer at the head of the patient, after loosening the chin straps, pulls the helmet off the victim's head. Because helmets are egg-shaped, care must be taken to expand the helmet laterally to prevent injury to the ears. After the helmet is removed, the first rescuer places his or her palms over the ears of the patient, the thumb in the temporal region, and the fingers along the zygoma (cheekbone), shaft of the mandible, sternomastoid muscle, and occiput to apply appropriate in-line traction (see Fig. 9.19).

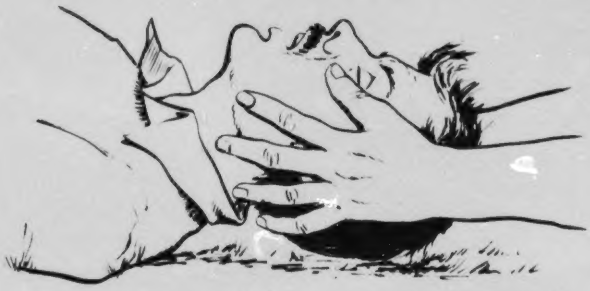

**Figure 19. In-Line Traction**

Arm slings may be fashioned from cravats (triangular bandages) or kerchiefs and are particularly useful when supplementing the rigid splints of the upper extremity, further immobilizing the area and relieving the weight.

To apply a sling, the splinted extremity should be placed in a comfortable position across the chest (see Fig. 9.20). The long edge of a triangular bandage is then laid along the patient's side opposite the injury. The bottom edge of the bandage is brought up over the forearm and tied to the side of the patient's neck. The pointed edge of the sling, at the elbow, is tied or pinned to form a cradle.

The sling and swathe provide further immobilization and are particularly useful in stabilizing clavicular fractures. The sling is applied in the aforementioned manner, and then one or two wide cravats are applied around the body and tied firmly in place (see Fig.

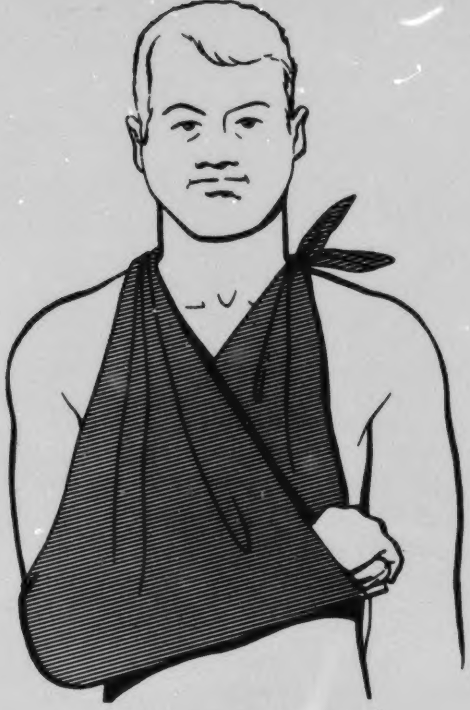

Figure 20. Arm Splint

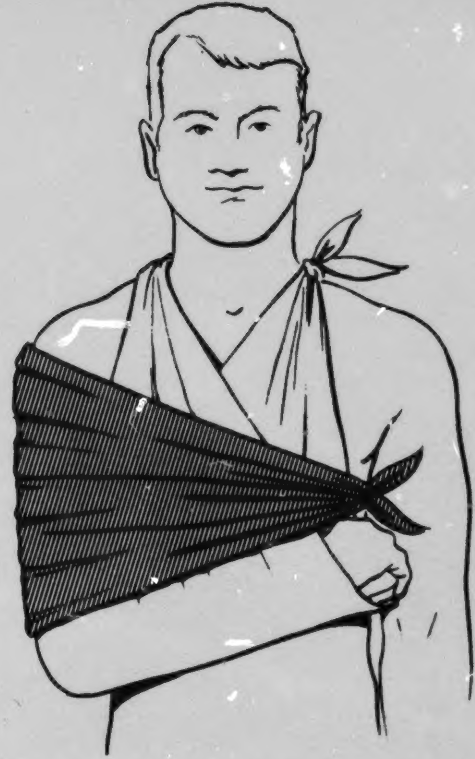

Figure 21. Swathe

9.21). Self-adhering bandages, elastic bandages, or roller bandages can also be used.

A pillow splint immobilizes an injured foot. An ordinary pillow is molded around the foot in a position of comfort and is secured with several cravats (see Figs. 9.22 and 9.23).

### MILITARY ANTI-SHOCK TROUSERS.

MAST are, in effect, a type of air splint. MAST may be used for lower extremity trauma and is especially useful for pelvic fractures. Caution must be exercised to avoid overinflation.

## Management of Orthopedic Injuries—Fractures

### CLAVICLE.

Clavicular fractures, usually midshaft, can be detected by palpation and observation along the shaft of the clavicle. They most frequently occur in children, and there is usually good approximation of the bony fragments.

You can obtain immediate stabilization by using the sling and swathe to prevent shoulder motion. Better yet, is a figure-of-eight bandage, which holds both shoulders in a very militarylike fashion. Padding should be placed beneath the axilla (armpit) to protect the axillary artery and veins and the brachial plexus (nerves of the neck and axilla). Always check the radial pulses after application of a figure-of-eight bandage to make sure that the blood flow to the arms has not been compromised.

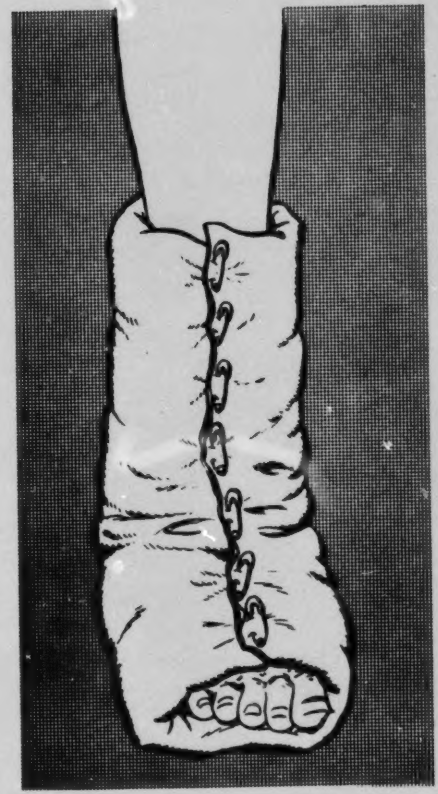

Figure 22. Pillow Splint

Laceration of the subclavian artery or vein by a spicule of bone from a fracture rarely occurs. If blood loss occurs, it is contained within the retroclavicular area and is sometimes difficult to detect. Pneumothorax (the presence of air or gas in a pleural cavity) is even rarer.

### HUMERUS.

Proximal fractures of the humerus are usually sustained by falling on an outstretched arm. The diagnosis is sometimes difficult in such proximal fractures because the broken parts are frequently impacted. Palpation throughout the length of the humerus, three-point manipulation, and rotation of the humerus can identify the presence or absence of most humerus fractures. Fractures of the shaft usually cause gross deformity, swelling, and pain. In proximal head fractures, pain and tenderness beneath the deltoid muscle or near its insertion may be the only symptoms; but in a fracture of the shaft, the patient will not be able to move the arm.

The most effective method of stabilization is to sling and swathe to immobilize the fracture against the chest. Wood splints can be added for protection, but cannot be used alone because they do not immobilize the joint above the fracture. Initial stabilization can also be accomplished by using a long backboard and sandbags and keeping the patient's upper arm at his or her side and the forearm across the abdomen.

### HAND.

Fractures of the metacarpals and phalanges may be either impact or incomplete greenstick. Frequently diagnosis is based on pain alone. A typical "boxer's fracture" of the fifth metacarpal can result when the victim delivers a punch. This produces a slight palmar angulation of the distal third and can be most easily detected by posterior palpation.

Vascular and nerve impairment may occur. When faced with such complications, the distal fragment should be brought in line with the proximal fragment to try to reestablish blood flow. If this realignment of parts is not readily performed, the patient should be transported promptly to the hospital. Warn the hospital that a patient with such complications will be arriving.

### ELBOW (DISTAL HUMERUS AND PROXIMAL RADIUS AND ULNA).

Fractures at the elbow are frequently supracondylar humeral fractures. Children are frequently the victims. The resultant pain and inability to move the elbow after palpation signal this fracture. These fractures are particularly serious because of the proximity of the fragments to nerves and blood vessels.

Elbow fractures are the most frequent type of fracture associated with severe vascular compromise. Decreasing the angle of the elbow by manipulation can sometimes relieve vascular obstructions. However, because of the close approximation and the restriction of vascular movement, operative intervention and/or vascular repair is frequently necessary to reestablish blood flow to the extremity. If you are within 30 minutes of a hospital, bring the patient in promptly rather than attempting any on-the-scene manipulation.

### FOREARM (SHAFT AND DISTAL RADIUS AND ULNA).

Fractures of the forearm are usually produced by a fall on the outstretched arm. Shaft fractures of the radius and ulna and distal fractures are diagnosed by palpation, three-point pressure, and rotational movements from pronation (palms down) to supination (palms up). Even though midshaft fractures usually produce great deformity, it is not uncommon for fractures (particularly in the elderly) to be impacted and relatively stable. Therefore, roentgenographic evidence is necessary to confirm that no fractures exist.

Frequently the best method of managing this fracture is to apply a sling and swathe along with a ladder splint or short board splint to stabilize the wrist. Complete immobilization must include the joint above the fracture, the elbow. This means, of course, that pneumatic splints or rigid long board splints must immobilize the arm in full extension. It is frequently difficult to transport the patient in this position, and it is uncomfortable for the patient.

A hemorrhage of 250 to 500 cubic centimeters (cc) of blood can occur in the area of the fracture.

The fracture should be immobilized with 4-inch-square gauze pads and a sling applied in the position of function. Straight splints such as tongue depressors or short pneumatic splints can also be used. Complications of these fractures are minimal.

### PELVIS.

A fractured pelvis commonly results from compression injuries and falls. Bilateral pressure applied to the anterior superior iliac spines can elicit pain on movement of the pelvis, as can pressure over the symphysis pubis or bilateral pressure over the greater trochanter.

Long backboards or MAST's can immobilize such fractures. MAST's provide the added benefit of stopping any bleeding (hemostasis). Intravenous fluid replacement must be carried out. Scoop stretchers can be used to move the patient onto a long backboard but are seldom enough on their own to provide stabilization.

Blood loss from pelvic fractures is probably the most extensive of any fractures. Two to two and a half liters of blood can leak into the retroperitoneal space. Shock can develop from this fracture alone. Therefore, MAST's are especially beneficial in the management of these patients. The MAST is useful for hemostasis and volume replacement. Intravenous infusions are generally easier to start after the MAST has been applied because the veins are fuller.

### HIP.

Fractures of the hip can either be of the acetabulum, the surgical neck of the femur, or the shaft near the trochanters and are caused generally by a fall or some other type of trauma, such as hitting the dashboard with the knees in a head-on automobile crash. Shortening and external rotation of the leg and pain when moving the extremity are frequent physical findings.

Traction splints (Thomas half ring or Hare traction splint) are preferred for management of this type of fracture, although a long spine board or the MAST can also provide immobilization. Keep in mind that blood loss is usually minimal, but can approach 250 to 500 cc.

### FEMUR.

Tenderness or midshaft angulation of the femur are the most common physical findings. Three-point pressure and rotation of the extremity can be helpful in Management of this fracture is similar to management of hip fractures; traction splints are preferred. Pneumatic splints other than the MAST do not immobilize the joint above the fracture. They can instead provide a fulcrum for movement and be more harmful than no splint at all. Vascular impairment can occur, with blood loss from 750 to 1,250 cc. Traction splinting of the leg should relieve most vascular impairment. The simultaneous use of traction splinting and MAST is often necessary in severe hip or femur fractures when hypovolemic shock—caused by a drastic reduction in the body's plasma—is present or is likely to develop. When this is necessary, apply the MAST *over* the traction splint.

### KNEE.

Fractures of the knee, like those of the elbow, are frequently supracondylar. Impaction with minimal angulation may make these fractures difficult to identify, except by testing for tenderness.

When treating a fracture of the knee, as in all femoral fractures, the knee must be immobilized. Therefore, similar management techniques as with the hip and femur are used. However, pain and occasional angulation of this fracture may prevent the use of traction splinting. Therefore, splinting the knee in the position most comfortable to the patient may require the use of wire splints, such as the ladder splint.

The position of the fracture causes vascular complications similar to those in elbow fractures. Therefore, an attempt to reestablish impaired circulation is necessary, but may not be successful. Only minimal pressure should be used to correct the deformity. Patients with knee fractures should receive treatment and transportation before those with fractures in the shaft of the femur devoid of vascular impairment.

### TIBIA AND FIBULA.

Fractures of the tibia and fibula, particularly those near the ankle, resemble a sprain or strain and can be difficult to identify. Although angulation may be present in the midshaft, pain and tenderness may be the only evidence of injury distally.

Long leg pneumatic splints, traction splints (Thomas half ring or Hare), or board splints are all acceptable methods of immobilizing this fracture. The MAST does not immobilize the ankle and, therefore, cannot be used as immobilization for below-the-knee fractures.

Vascular complications, particularly around the ankle, are not uncommon, especially if a fracture dislocation at the ankle has occurred. If vascular impairment is secondary to a fracture dislocation, reduction should be attempted in the field even though the wound may be open.

### FOOT.

Like fractures of the hand, fractures of the metarsals and phalanges are relatively benign and can be detected by palpation. Immobilization with a short pneumatic splint (pillow or rigid), angulated to fit the foot, is appropriate stabilization. Complications rarely occur with these fractures. However, patients with heel fractures from falls should be examined for fractures of the hip or spine.

## Management of Orthopedic Injuries—Dislocations

Generally, dislocations should be immobilized as they are found unless definitive treatment is more than an hour away or there is an absent pulse distal to the injury. Usually dislocations are most easily treated shortly after they occur, before severe muscle spasms develop. Although dislocations can involve any joint, those that involve the shoulder, the carpal-interphalangeal, ankle, metacarpal-phalangeal joints in the lower extremity, and radial head dislocations in the small child are most amenable to early management.

Fractures can accompany dislocations; X-rays of the area must be taken after reduction. If reduction is painful, abandon further attempts until roentgenographic evidence is available to pinpoint the extent of the injury.

Frequently, dislocations are compounded by joint, capsular, or ligamentous impingement that prevent reduction. After reduction of the dislocation, immobilization must be accomplished as if the dislocation were a fracture.

### SHOULDER.

A depression above or below the glenoid joint and restricted motion will identify this dislocation. Immobilize the upper arm in the sling and swathe, padding the armpit. Frequently it may be necessary to use a pillow or blanket between the arm and the chest wall because the arm is fixed away from the chest. In patients with recurrent shoulder dislocations, the following procedure could be attempted: Place the patient in a prone position on a stretcher, the arm on the injured side dangling off the stretcher to its full length. Instruct the patient to hold an empty bucket while water is slowly poured into it (adding increased weight). By so doing, the shoulder dislocation may be reduced. Another method to produce reduction is to tape a 10- to 15-kilogram sandbag to the dangling hand. Generally, it is not necessary to attempt this in the field.

### ELBOW.

Dislocation of the elbow in a small child (nursemaid's elbow) is diagnosed by painful movements of the elbow joint. The dislocation occurs when the child's full weight is supported on the extended arm.

The elbow should be immobilized with the sling and swathe or with a long arm padded splint. Full 180° extension or flexion of less than 90° should be avoided to diminish the chances of vascular compromise. Attempts at reduction by movement of the wrist from extreme pronation to extreme supination while flexing the elbow should be made only when there is vascular compromise and medical care is more than 30 minutes away.

### PHALANGES.

Both metacarpal-phalangeal and interphalangeal joint dislocations are identified by obvious deformity of joints and painful movement. Dislocations of the metacarpal-phalangeal and interphalangeal joints of the foot are managed like those of the hand—by splinting in a position of function.

Stabilization of the fracture and/or dislocation to an adjacent toe with tape, placing padding between the toes, is sufficient. Traction applied proximally and distally to the involved joint relaxes the muscular spasm, allowing movement of the articular surfaces into their normal position. If reduction is performed, take an X-ray to rule out any associated fracture.

### ANKLE.

Dislocations of the ankle are frequently associated with fractures. Generally, there is gross deformity of the ankle, but often it is not possible to distinguish a fracture from a dislocation.

Treat ankle dislocations as if they were fractures—immobilize the ankle with either leg splints, air splints, or a pillow splint. If there is vascular compromise, reduction should be attempted. Placement of one hand over the Achilles tendon at its attachment to the calcaneus (heel bone) and the other hand over the dorsum (back) of the foot puts the hands in the proper position to apply traction. Frequently, much traction is necessary to return the foot to its proper position. Assistance from a partner is required to provide countertraction and is best accomplished by applying a hand to the knee.

If the reduction does not occur readily in a patient with vascular compromise, the patient should be transported to the hospital immediately.

## Glossary

**cartilage:** A tough, white connective tissue that covers the joint surfaces of bones.

**cravat:** Triangular bandage that is used for fashioning a sling or swathe.

**crepitation:** Crackling; the sensation felt or heard over the fracture site when broken bone ends rub together.

**diaphysis:** The main, central shaft of a long bone.

**dislocation:** Displacement of a bone and from its joint.

**ecchymosis:** The purplish discoloration of skin caused by the passage of blood from ruptured blood vessels into subcutaneous tissue; bruise.

**epiphysis:** The end portions of a long bone.

**fracture:** A break in the continuity of bone.

- **closed fracture:** One in which the skin overlying the site is intact.
- **comminuted fracture:** One in which the bone is broken into more than two pieces.
- **greenstick fracture:** An incomplete fracture commonly found in children.
- **impacted fracture:** One in which the broken ends of the bone are jammed together.
- **oblique fracture:** One in which the fracture line crosses the bone at an oblique angle or in a slanting direction.
- **open fracture:** One in which there is an open wound over the fracture site.
- **spiral fracture:** One in which the fracture line twists around and through the bone.
- **transverse fracture:** One in which the fracture line is straight across at a right angle to the long axis of the bone.

**immobilization:** Prevention of movement or use of an injured structure.

**ligament:** A strong band of tissue that connects two or more bones.

**marrow:** The soft, fatty substance that fills the medullary canal; responsible for the formation of blood.

**medullary canal:** The hollow central portion of the bone; contains the bone marrow.

**periosteum:** The outermost layer of bone.

**position of function:** Maintenance of the curve of the hand by use of a roll bandage when immobilizing the wrist, hand, or finger.

**reduction:** Restoration of the ends of a fractured bone to their normal anatomical position.

**sling:** A bandage that is suspended from the neck to support an injured arm or head.

**splint:** Any device used to immobilize a fracture or dislocation.

**sprain:** Injury in which ligaments are partially torn.

**strain:** Soft-tissue injuries or muscle spasms around a joint.

**swathe:** A bandage used in conjunction with a sling that is wrapped around the body to secure the injured arm.

**tendon:** A fibrous cord or band that connects a muscle to a bone.

**traction:** Method used to realign fractures and dislocations by application of a pulling force to the site

**windlass:** Device on a Thomas half ring splint that creates pull by winding rope around a handle.

## Reference

American Academy of Orthopedic Surgeons. *Emergency Care and Transportation of the Sick and Injured.* Chicago: Author, 1977.

## Module X.
# Medical Emergencies
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# Module X.
# Medical Emergencies

Most medical emergencies that are encountered by paramedics have been discussed in other chapters of this Manual; presented below are only those emergencies that have not been dealt with before.

## Unit 1. Diabetic Emergencies

Diabetes mellitus is a disease that occurs when the pancreas cannot secrete enough insulin to control blood glucose levels (see Module II). Insulin is a hormone produced by beta cells in the islets of Langerhans of the pancreas. When blood glucose rises, the beta cells release more insulin into the bloodstream, which increases glucose transport into muscle and fat cells. (In addition, insulin promotes the synthesis of glycogen [a large-storage form of glucose], large fat molecules, and protein). Many diabetics take insulin shots to compensate for their insulin deficiency. However, regulating the amount of glucose in the blood requires a delicate balance, and the insulin dose taken may be either too high or too low. When diabetics take too little or too much insulin, their blood sugar level becomes either too high (hyperglycemia) or too low (hypoglycemia).

### Diabetic Ketoacidosis

Diabetic ketoacidosis occurs when the blood sugar level becomes too high—either because the insulin dose is too small or because it has been neglected. Ketoacidosis is often precipitated by stress, such as that caused by infection. When serum insulin is low, glucose cannot enter the muscle and fat cells and instead accumulates in the blood. When insulin levels fall, glycogen breakdown increases; this forms more glucose, which enters the bloodstream, increasing blood glucose levels further.

The increased number of glucose molecules in the blood increases the blood's osmotic pressure. In addition, the kidneys, which normally reabsorb all glucose, begin to excrete glucose, increasing the osmotic pressure in the urine. Because the kidneys can only concentrate urine to a certain osmotic pressure, they must excrete more water when they excrete glucose. Therefore, increased blood glucose produces osmotic diuresis (increased urine output).

If the diabetic does not drink enough water to match the increased water excretion, he or she will become dehydrated. Dehydration may be so severe that it produces hypovolemic shock.

When insulin levels decrease, fat breakdown increases to provide an alternate energy source for cells that can no longer use glucose. Fat breakdown products are acids, which are called either ketoacids or ketone bodies.

When more ketoacids are produced than the kidney can excrete, they accumulate and produce metabolic acidosis (see acid-base balance and metabolic acidosis in Module III). The lungs attempt to compensate for the metabolic acidosis by increasing the rate and depth of respiration to blow off more carbon dioxide and return the pH to normal (7.4). This is called Kussmaul's breathing.

When the kidneys excrete ketoacids, they also excrete potassium. Serum potassium levels do not fall, however, because potassium leaves the cells (where most body potassium is found) when the body becomes acidotic. In fact, serum potassium may actually rise. Dangerously low serum potassium levels may occur later, however, when ketoacidosis is corrected; this condition occurs because potassium reenters the cells when the pH returns to normal.

The patient in diabetic ketoacidosis has a characteristic fruity-smelling breath due to the presence of acetone, a ketone body. Diabetic ketoacidosis usually progresses slowly, over 12 to 48 hours, with the patient gradually becoming comatose. The symptoms of diabetic ketoacidosis are:

- Polyuria (excessive urine output) due to osmotic diuresis.
- Polydipsia (excessive thirst) due to dehydration.
- Polyphagia (excessive hunger), probably due to the body's inefficient use of nutrients.
- Nausea and vomiting, the latter worsening with dehydration.
- Tachycardia.
- Deep, rapid respirations (Kussmaul's breathing), in an attempt to blow off excess acids by carbon dioxide elimination.
- Warm, dry skin and dry mucous membranes, reflecting dehydration.
- A fruity odor on the breath, due to acetone.
- Occasional fever, abdominal pain, and falling blood pressure.

The treatment of ketoacidosis in the field depends on the diagnosis. It is safer to assume the patient in coma is suffering from hypoglycemia than hyperglycemia (see below). If, however, the patient's history and physical exam are consistent with ketoacidosis, the paramedic should start treatment aimed at hydration and supporting vital functions and administer 25 to 50 cubic centimeters (cc) of 50 percent glucose intravenously (IV). To treat suspected ketoacidosis, you should:

- Follow the usual procedures for airway maintenance and oxygen administration in comatose patients. Be alert for vomiting and have suction equipment ready.
- Start an IV, draw blood for serum glucose determination, and hang 1 liter (l) of normal saline at the rate ordered by the physician. The patient in ketoacidosis is severely dehydrated, often to the point of shock, and needs fluid volume.
- Monitor cardiac rhythm. Changes in serum potassium caused by acidosis can lead to marked cardiac instability. Note the contour of the T waves on the rhythm strip; if they are sharply peaked, the patient's potassium level may be dangerously high, and bicarbonate may be indicated.

## Hypoglycemic Reactions

Hypoglycemia in the insulin-dependent diabetic is often the result of having taken too much insulin, too little food, or both. The brain depends on a constant glucose supply for its function. If the glucose level falls very low, the brain is unable to function properly. This causes severe excitement and then depression or, in extreme cases, convulsions followed by coma. In contrast to ketoacidosis, hypoglycemia develops very rapidly. It should be suspected in any diabetic manifesting bizarre behavior, altered neurologic signs, or paranoia, hostility, or aggression. The symptoms of hypoglycemia include:

- A weak, rapid pulse.
- Cold, clammy, pale skin.
- Weakness and incoordination.
- Headache.
- Irritable, nervous, or bizarre behavior.
- In severe cases, seizures and coma.

Treatment for the patient with severe hypoglycemia involves restoring glucose levels to normal. To effect this, the paramedic should:

- Treat the patient in coma as any other comatose patient, by establishing an airway and administering oxygen. Start an IV, draw blood for lab tests, and hang 5 percent dextrose (D5W) to keep the vein open. Then give 50 milliliters (ml) 50 percent dextrose by IV push. If the coma is indeed caused by hypoglycemia, the patient will awaken dramatically. If unable to start an IV in the comatose patient, use glucose paste smeared across the mucosa inside the cheeks.
- Give orange juice sweetened with sugar, cola, or candy instead of D5W IV if the patient is awake, alert, and able to swallow.

It is important to note that diabetics are not the only patients who are prone to hypoglycemia. Alcoholics, patients who have ingested certain poisons, and others may develop the same syndrome. The paramedic should not, therefore, discount the possibility of hypoglycemia in a comatose patient. This is particularly true with an auto accident victim when there appears to be no real reason for the patient to be in a coma.

In summary, remember:

- Any patient in a coma of unknown cause should receive glucose.

- Diabetics have problems with both hyperglycemia and hypoglycemia. When in doubt, give glucose. A hyperglycemic patient will not be harmed by receiving glucose (the amount administered is small compared to the amount already in the blood), and a hypoglycemic patient will respond dramatically.

## Unit 2. Anaphylactic Reactions

Anaphylaxis is a rapid, serious allergic reaction that occurs within seconds or minutes after patients contact substances (antigens) to which they have previously been sensitized. Anaphylaxis is most frequent after injection of an antigen—usually an insect sting, an IV, or an intramuscular injection. Anaphylaxis also occurs occasionally after injection of a drug like penicillin or inhalation of ragweed or other pollen.

An antigen is any substance that is foreign to an individual and that causes antibody production. Antigens include drug molecules, serum from other animals (e.g., horse serum), and blood from individuals of different blood types.

Antibodies are produced to help eliminate antigens from the body. However, in cases like anaphylaxis, the reaction to the antigen is more harmful than the antigen itself.

An individual becomes sensitized to an antigen through contact. The body produces antibodies to the antigen; these antibodies attach to the antigen that caused their formation. During sensitization, antibodies specific to the sensitizing antigen attach to mast cells, which contain histamine and heparin. When the individual again comes in contact with the antigen, the antigen attaches to the antibody on the mast cells. This causes the mast cells to release histamine and heparin.

Histamine dilates arterioles, increases capillary permeability (leakiness), and constricts smooth muscle, including bronchial and laryngeal smooth muscle. Increased flow through capillaries and increased capillary permeability produce tissue edema, including laryngeal edema. They also reduce circulating blood volume and produce hypovolemic shock. Constriction of bronchial and laryngeal smooth muscle produces bronchospasm and laryngospasm, or narrowing of the airways.

Heparin, the second product released by mast cells, interferes with blood clotting. Therefore, hemorrhage may occur in anaphylaxis.

The patient experiencing an anaphylactic reaction is extremely dyspneic and is often sneezing, wheezing, or coughing up blood-tinged sputum. The patient frequently complains of tightness in the chest or a sensation that his or her throat is closing. The patient's face may be flushed or ashen, with marked swelling, especially around the eyes. Sometimes the patient will complain of severe itching, either generalized or in the throat. The patient will often have hives (urticaria), or the skin may simply become red and inflamed. Abdominal cramps, followed by nausea, vomiting, and diarrhea, are common. The pulse is usually rapid, and the blood pressure is falling, sometimes to the point of circulatory collapse. The sequence of itching, coughing, dyspnea, and cardiorespiratory arrest may occur within seconds, and death is imminent unless proper treatment is begun immediately. The paramedic should:

- Establish an airway and administer oxygen. In cases of airway obstruction from severe glottic edema, cricothyroidotomy (cutting open the throat) may be necessary.
- If the reaction results from an insect sting or injection, place a venous tourniquet above the site of the injection. Obviously this will only be possible if the injection site is on an extremity. Apply the tourniquet for 15 or 20 minutes; then release it for 3 to 5 minutes. Reapply it if the reaction persists.
- Give 0.5 ml of 1:1000 aqueous epinephrine subcutaneously below the tourniquet and another 0.5 ml of 1:1000 aqueous epinephrine by deep (SC) injection in the other arm (adult dose). Massage the site to enhance absorption. One 0.5 ml dose may be repeated in 20 minutes if the symptoms are still present.
- If the patient does not immediately respond to the SC epinephrine, start an IV with normal saline in dextrose (D5W NS) and administer 1.0 to 2.0 ml of 1:10,000 epinephrine slowly IV. If unable to start an IV in a patient who does not respond to SC epinephrine, give 0.5 ml of 1:1000 aqueous epinephrine centrally into the posterior vascular plexus at the base of the tongue (inferior surface).
- If shock is profound, start an IV with D5W NS and administer 10 ml of 1:10,000 epinephrine slowly IV. Again if an IV in a patient with a severe reaction is difficult to start, give 0.5 ml of 1:1000 aqueous epinephrine centrally into the posterior vascular plexus at the base of the tongue (inferior surface) or directly into the trachea. (Absorption here is almost as fast as IV.)
- Consider the use of the following medications when appropriate:

—Aminophylline, dosage 250 milligrams (mg) in 100 cc D5W added to Buretrol.

—Norepinephrine, dosage 2 cc in 250 to 500 cc D5W.

—Hydrocortisone, 100 mg ready in a syringe.

—Aramine, dosage titrated to patient's blood pressure; by physician order.

—Diphenhydramine, dosage 5 to 20 mg IV, indicated to counteract histamine.

- Use normal saline or Ringer's solution to correct hypovolemia resulting from arteriolar dilation and increased capillary permeability. Norepinephrine is sometimes used in severe hypotension, but this is dangerous. If norepinephrine is ordered, draw up 2 ml and add it to a 250-ml bag of D5W. Label the bag.

- Transport the patient rapidly to hospital when the situation is under control.

## Unit 3. Exposure to Environmental Extremes

This unit discusses some basic concepts concerning the body's mechanisms for maintaining an optimum core temperature and specific emergency treatment for patients exposed to extremes of heat and cold.

### Temperature Regulation

To understand body temperature regulation, it helps to understand some basic terms and concepts. The body is divided into two functional areas for temperature control: a core area and a peripheral area. The body core includes part of the skeletal muscle and the contents of the body cavities—skull, vertebral column, thorax, abdomen, and pelvis. The peripheral area is the area where heat transfer between the body and the environment occurs; it includes the skin and subcutaneous tissues.

The body carefully maintains a temperature in the core of 37° C (98.6°F). The rectal temperature is closest to the core temperature; oral temperatures are below core temperature.

In contrast to the core temperature, the peripheral temperature varies. Temperatures in the peripheral area are slightly below those in the core at room temperature. When the body is exposed to cold, the peripheral areas become even colder—as much as 15°F below the core temperature.

Heat is formed by food breakdown. Skeletal muscle and liver produce the greatest amount of heat. Heat formed by skeletal muscle is most important in temperature control, because muscle activity can be increased to increase heat production when more heat is needed. For this reason, the cold person voluntarily walks or runs, or involuntarily shivers, to increase heat production.

The liver and body tissues also break down food faster when the environment is cold. The rate of food breakdown by these tissues is called the metabolic rate. The metabolism speeds up in the cold in response to epinephrine, which is released by the adrenal medulla following stimulation of the sympathetic nervous system. Heat transfer between the body and the environment occurs in the peripheral area through the skin and large airway linings. There are two mechanisms for heat transfer: heat flow from warmer to colder areas and heat loss through evaporation of water from the body surface.

Heat flows from areas of higher temperature to areas of lower temperature. Temperature differences between two areas are referred to as a temperature gradient; movement of heat from a warm area to a cold area is called heat flow down a temperature gradient. The rate of heat transfer depends on the size of the temperature gradient, that is, the amount of temperature difference between the two areas.

The body can also lose heat by water evaporation, whatever the environment, warm or cold. Evaporation means that water is changing from a liquid to a gas. This change requires heat; the heat used to evaporate water is lost from the body surface.

Thus, there are two ways in which heat can be lost from the body: First, down a temperature gradient into a cold environment and, second, by water evaporation in either a cold or warm environment. The second means, heat loss by water evaporation, is possible only when the environmental temperature is higher than the body temperature.

The body can gain heat from the environment in only one way—by absorbing it from an environment that is warmer than the body. The body needs other mechanisms to raise its temperature in a cold environment.

Mechanisms for increasing body temperature include increasing heat production through muscle contraction and decreasing heat loss through vascular (blood vessel) mechanisms. Vascular mechanisms can decrease heat loss because blood in the body core is at the core temperature, but must travel through the peripheral area, where it loses heat to the environment. Therefore, the vascular mechanisms that decrease the amount of heat carried to the periphery by the blood vessels decrease the heat loss to the environment.

The body decreases heat loss from the peripheral blood vessels in two ways. First, skin arterioles vasoconstrict in response to sympathetic stimulation when the environment is cold. This reduces the amount of blood in the peripheral capillaries and thus reduces the amount of heat lost from these vessels.

Second, the arteries and veins travel near each other. This allows the warmer arteries leaving the body core to transfer heat to the veins returning to the core. The further the blood travels from the core, the colder it becomes. Conversely, blood returning in the veins becomes warmer as it travels toward the core. As the blood in the peripheral area becomes colder, the temperature difference between the body surface and the environment drops. The rate of heat loss decreases when the body surface temperature becomes nearer to that of the environmental temperature.

When the body is exposed to cold (anything below 25° C, or 77°F, which is normal room temperature), heat loss is initially large, because there is a large difference between body surface temperature and environmental temperature. As the peripheral area

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cools, a temperature gradient develops between the core and the periphery. This temperature gradient is maintained by transfer of heat from arteries leaving the core to adjacent veins returning from the periphery.

In addition, the sympathetic nervous system stimulates skin arterioles to vasoconstrict. This reduces blood flow in the skin capillaries and, thus, reduces heat loss from them.

Heat production increases when the body is exposed to a cold environment. Epinephrine, released by the adrenal medulla in response to sympathetic stimulation, increases metabolic rate. Muscle activity also increases. Thus, the cold person will usually walk, run, or move about voluntarily and will shiver involuntarily to increase body temperature.

Additionally, small muscles connected to individual hairs contract, making the hairs stand on end, producing what is called "gooseflesh." In hairy and feathered animals, gooseflesh traps air near the skin to insulate it to some extent against heat loss. Humans, however, do not have enough body hair to trap air—all that remains of this protective mechanism is the appearance of gooseflesh.

A hot environment is one that is above normal room temperature (25° C). When the environmental temperature rises, heat produced through metabolism accumulates in the body. To lose this heat, skin arterioles dilate. Vasodilation effectively increases heat loss as long as body temperature is higher than environmental temperature. When the outside temperature rises above body temperature, however, vasodilation becomes harmful, since it increases heat absorption by increasing the amount of blood available to absorb heat.

A second means the body uses to throw off heat, water evaporation, works in environments above and below body temperature. It is the only mechanism available to dispose of heat when the body is cooler than the environment. Water evaporates from both the large airways (the breath) and the skin surface (sweat).

How much water evaporates from the airways and the skin depends on the relative humidity, that is, the amount of water vapor in the air compared to the maximum amount that *could* be in the air. As the relative humidity rises, less water evaporates from the body. Conversely, when the relative humidity is low (and the air is dry), more water evaporates. Thus, hot, dry climates are more comfortable than hot, humid climates.

The evaporation of sweat from the skin is also affected by the amount of clothing worn and the rate of air flow past the skin surface. Wearing fewer clothes increases water evaporation; wearing more clothes decreases water evaporation. Likewise, greater air flow (from a fan or breeze) increases water evaporation and less air flow decreases it.

Sweating is produced by sympathetic nerves. Sweat is a diluted solution of sodium chloride (common salt). A normal adult can sweat about 1 liter per hour; this effectively reduces body temperature but depletes the body of water and sodium.

## Emergencies Due to Heat Exposure

Heat cramps are muscle pains, usually in the legs or abdomen, that result when profuse sweating depletes the body of salt. They usually afflict people in good physical condition who overexert themselves in sports or overwork when the heat and humidity are high. Heat cramps usually begin suddenly during vigorous activity. They may be mild, with only slight abdominal cramping and tingling in the extremities. Often, however, they produce severe and incapacitating pain in the extremities and abdomen. The patient may become hypotensive and nauseated, but the patient's mind will remain clear. The pulse is generally rapid and the skin pale and moist, but the temperature is usually normal. If untreated, heat cramps may progress to heat exhaustion.

One treats heat cramps by getting patients out of the heat and restoring their lost salt and water. You should:

- Move the patient to a cool place and have the patient lie down if he or she feels faint.
- Give one or two glasses of salt-containing solution (lemonade with half a teaspoon of salt added or a commercial preparation that contains sodium like Gatorade or Take Five) if the patient is not nauseated. Have the patient drink slowly. Salt tablets are not as good a remedy because they may cause or worsen nausea.
- If the patient is too nauseated to take liquids by mouth, start an IV with normal saline at a rapid rate.
- Do not massage the cramped muscles. This rarely helps and may actually worsen the pain.
- Advise the patient not to return to strenuous activity for at least 12 hours. As salt and water are replaced, the patient's symptoms will disappear. The patient may want to resume earlier activities, but you should make it clear that further exertion may lead to heat exhaustion or heat stroke. Also advise the patient to salt food more heavily and increase fluid intake until cramps stop.

Heat exhaustion represents a somewhat more severe response to salt and water loss as well as to peripheral blood pooling. Like heat cramps, heat exhaustion also tends to occur in persons working or exercising in hot environments. Heat exhaustion, however, is especially likely in elderly, dehydrated patients and in hypertensive people. The elderly are more prone to the problem because of their diminished thirst mechanism, which reduces their intake of fluids even when they are dehydrated.

Heat exhaustion may come on suddenly, with syncope and collapse, or may be heralded by such symptoms as headache, fatigue, dizziness, nausea, and, sometimes, abdominal cramping. The patient is usually perspiring profusely, and the skin is pale and clammy. The patient may also be disoriented. The body temperature is either normal or decreased, the pulse is rapid and weak, and breathing is usually fast and shallow. Blood pressure may be decreased due to peripheral pooling of the blood, and the pupils may be dilated. Untreated heat exhaustion may progress to heat stroke.

Treatment of heat exhaustion is similar to that for heat cramps. The paramedic should:

- Move the patient to a cool place, take off as much of the patient's clothing as possible, and place him or her supine, with legs elevated.
- Sponge the patient with cold water or alcohol, and fan the patient if the humidity is not excessively high. (Avoid chilling the patient; just make him or her comfortably cool.)
- Start an IV with normal saline and run fluids rapidly, about 150 to 200 ml per hour. It is best to avoid fluids by mouth, especially if the patient is nauseated.

Heat stroke is caused by a severe disturbance in the body's heat-regulating mechanism and is a profound emergency with a mortality rate of 25 to 50 percent. It occurs most frequently in men over 40, especially alcoholics. It may occur, however, at any age, in any person who has been exposed to the sun too long or who has been confined in a hot area. Heat stroke begins suddenly. As the sweating mechanism fails, the body temperature rises rapidly, reaching 106°F or more within 10 to 15 minutes. If the temperature is not reduced rapidly, the body cells—especially the very vulnerable cells of the brain—are literally cooked, and there is irreversible brain damage.

Unlike the patient with heat exhaustion, the patient with heat stroke has hot, flushed, dry skin and a bounding pulse. Initially the patient may experience headache, dizziness, and dry mouth. Coma and seizures often follow rapidly.

Treatment of heat stroke is aimed at maintaining vital functions and reducing the temperature as rapidly as possible. To do this, you should:

- Establish an airway and administer oxygen.
- Move the patient to a cool environment, take off as much of the patient's clothing as possible, and place the patient in a semireclining position with the head elevated.
- Use any means available to rapidly cool the patient. Improvise with whatever is available—a bathtub filled with cool water and ice cubes is ideal. Otherwise, use an ice-cold shower, crushed ice rubbed over the patient's body, a garden hose, cold packs, or continued washings with rubbing alcohol. Wrapping a wet sheet around the patient's body and then directing an electric fan at the patient is also a good means of cooling. The scalp and neck are both areas of rapid heat loss; ice packs placed there, especially over the carotid artery, are beneficial. Any of these methods will do, but speed is vital, since delay may cause permanent brain damage. Record the patient's rectal temperature frequently. Continue vigorous efforts to cool the patient until the temperature is below 102° F.
- Start an IV with D5W. Use iced IV solutions and give hypertonic glucose. Patients with heat stroke, however, are unusually susceptible to congestive heart failure, so do not infuse IV solutions rapidly unless the patient is hypotensive.
- Prevent shivering and resultant further heat production by giving 50 mg chlorpromazine (Thorazine) or 10 mg diazepam (Valium) in an IV.
- Monitor cardiac rhythm throughout transport.

Table 10.1 summarizes emergencies due to heat exposure.

**Table 10.1.—Emergencies Due to Heat Exposure**

| | Heat Cramps | Heat Exhaustion | Heat Stroke |
|---|---|---|---|
| Pathophysiology. | Salt and water loss. | Salt and water loss; peripheral blood pooling. | Failure of heat-regulating mechanism. |
| Cramping | Present | May be present. | Absent. |
| Mental state. | Clear | May be disoriented. | Stupor or coma. |
| Skin | Cool, moist | Cool, pale, moist. | Hot, flushed, dry. |
| Temperature. | Normal | Normal or low. | Markedly high. |
| Pulse | Rapid | Rapid, weak. | Rapid, bounding. |
| Blood pressure. | May be low. | May be low. | May be high early. |
| Treatment | Salt and water; if tolerated orally. | Salt and water IV; cooling. | Oxygen; *rapid cooling;* keep open IV; monitor. |

## Emergencies Due to Cold Exposure

Emergencies due to cold exposure occur when the body's temperature-regulating mechanisms cannot maintain core temperature. As core temperature falls, the regulatory mechanisms become depressed.

When the core temperature falls below 34° F, the regulatory system falters. Ventilation diminishes as the system falters and as the respiratory control center becomes depressed. At the same time, both oxygen consumption and carbon dioxide production diminish due to decreasing metabolism. As the metabolism produces less heat, the core temperature falls lower, so the metabolism is thereby lowered even further.

When the core temperature falls 28°F, the regulatory mechanisms are overwhelmed, and the heart muscle is in danger. Atrial fibrillation is common at this point, and, as the core temperature declines, more serious arrhythmias may develop. The myocardium (the middle and thickest layer of the heart wall) is particularly irritable at this stage, and there may be ventricular fibrillation if the patient is handled roughly.

The lowest temperature one can survive in is usually considered to be about 23° F, although most patients with accidental hypothermia die sooner. One survival has been reported, however, in a patient whose core temperature plummeted to 10° F and, who, when found, had been in cardiac arrest for an hour.

This case illustrates the point that you should attempt to resuscitate every hypothermic patient, even when by ordinary standards the patient appears dead. When the core temperature falls below 30° F, heart sounds may not be audible even if the heart is still beating—tissues conduct sound poorly at low temperatures. Similarly, blood pressure may be unobtainable, and pupillary reflexes may be blocked. However, cardiac arrest is tolerated better at low temperatures. At 29.5° F, the brain can survive without blood circulation for about 10 minutes, and, at 20° F, it may survive for 25 to 30 minutes. Therefore, patients with accidental hypothermia merit extraordinary efforts, since they may not be dead.

Victims of near-drowning should be resuscitated according to the current standards of CPR. However, it is essential to ventilate the patient with as high a concentration of inspired oxygen as possible. The use of an oxygen-powered, positive pressure resuscitator is particularly advantageous in this regard.

General cooling, called hypothermia, is caused by prolonged exposure to low temperatures, especially when the weather is windy and wet. It most frequently occurs in alcoholics during the winter, but other persons, such as mountaineers, skiers, or elderly people living in poorly heated houses, may also develop hypothermia. Typically, the alcoholic, who is warmed and cheered by recent drinking, falls asleep in a doorway or alley and is too sedated by the alcohol to notice the further sedation produced by the cold. As the victim cools, he or she becomes lethargic, apathetic, and profoundly sleepy. As the patient cools further, loss of consciousness results. As pulse and breathing slow, bodily processes slowly stop. The patient dies if not discovered and treated promptly.

Hypothermia should be suspected in all patients with alterations in their mental state who have been exposed to the cold. A list of typical signs and symptoms is provided in Table 10.2.

Treatment is aimed at supporting vital functions and rewarming the patient. To treat the victim of hypothermia, the paramedic should:

- Establish an airway. If the patient is not breathing, intubate and ventilate. Never hyperventilate the patient. Extreme drops in carbon dioxide pressure may trigger ventricular fibrillation.

**Table 10.2.—Levels of Hypothermia**

| °F | °C | |
|---|---|---|
| 99.6 | 37.6 | "Normal" Rectal Temperature |
| 98.6 | 37 | "Normal" Oral Temperature |
| 96.8 | 36 | Increased metabolic rate in attempt to balance heat loss |
| 95.0 | 35 | Shivering maximum at this temperature |
| 93.2 | 34 | Patients usually responsive and normal blood pressure |
| 91.4 | 33 | *SEVERE HYPOTHERMIA BELOW THIS TEMPERATURE* |
| 89.6 | 32 | Consciousness clouded Pupils dilated Shivering ceases |
| 87.8 | 31 | Blood Pressure difficult to obtain |
| 86.0 | 30 | Progressive loss of consciousness<br>Increased muscular rigidity |
| 85.2 | 29 | Slow pulse and respiration<br>Cardiac arrhythmia develops |
| 82.4 | 28 | Ventricular fibrillation may develop if heart irritated |
| 80.6 | 27 | Voluntary motion lost along with pupillary light reflex, deep tendon and skin reflexes—appearance of death |
| 78.8 | 26 | Victims seldom conscious |
| 77.0 | 25 | Ventricular fibrillation may appear spontaneously |
| 75.2 | 24 | Pulmonary edema develops |
| 73.4 | 23 | |
| 71.6 | 22 | Maximum risk of fibrillation |
| 69.8 | 21 | |
| 68.0 | 20 | Heart standstill |
| 66.2 | 19 | |
| 64.4 | 18 | Lowest *accidental* hypothermic patient with recovery |
| 62.6 | 17 | ISO-ELECTRIC EEG |
| 48.2 | 9 | Lowest artificially cooled Hypothermic patient with recovery |

- Move the patient immediately to the ambulance.
- If the patient is unconscious, treat as usual for comatose patients (see Module VII).
- Remove any wet clothing from the patient.
- Apply monitoring electrodes. Hypothermia patients often develop ventricular fibrillation and must be monitored closely.
- Bubble oxygen through hot water and deliver it to the patient via a nasal catheter. This will warm the patient by first warming the core. Warming the skin before central warming may actually decrease the core temperature and bring on ventricular fibrillation.
- Start an IV with warm D5W so that medications can be given if cardiac arrest occurs. Warming the patient's arm may be necessary to find a vein.
- Transport the patient to the hospital rapidly.
- If cardiac arrest occurs en route, start cardiopulmonary resuscitation, intubate if possible, and move to the hospital without delay. Do not try to perform other advanced life-support measures in the field, because these efforts will fail unless the patient is rewarmed. Repeatedly defibrillating the patient will not restore the patient's heart rhythm if the body temperature is below normal. Resuscitating hypothermic patients often takes many hours and must be carried out together at the same time the patient is rewarmed.

Frostbite occurs when isolated parts of the body—most frequently the ears, nose, hands, and feet—are exposed to prolonged or intense cold. The exposed area first becomes red and inflamed, and then progressively turns gray or mottled white. If it becomes frozen, it will be white and waxy in appearance and feel stiff and hard. As these changes occur, the patient first experiences stinging and burning, followed by a pins-and-needles feeling (paresthesia), and finally stiffness, with complete loss of sensation in the affected area. As the area thaws, that patient experiences burning, often very intense pain, and the area becomes tender.

Treating frostbite involves careful rewarming and preventing further injury to the area. You should:

- Gently remove any clothing or covering from the affected area (for example, shoes and socks from frostbitten feet).
- Gradually rewarm a frostbitten extremity by immersing it in warm water (around 106° F—check it with the thermometer) for about 20 minutes. Then carefully dry the warmed area and cover it with a dry, sterile dressing. If the feet are injured, place sterile cotton between the toes.
- Cover a frostbitten nose or ears with a warm hand.
- Give the patient hot tea or coffee if available.
- Never attempt to rewarm a frostbitten area by rubbing or massaging. This will only increase tissue damage. Handle affected areas gently.
- Prevent the patient from smoking, as nicotine constricts the arterioles and further reduces blood flow to the affected area.
- Anticipate severe pain during thawing; morphine may be necessary.
- Transport the patient to the hospital as soon as possible, keeping the affected area warm and protected from injury. Do not allow a patient with frostbitten feet to put weight on them.

## Unit 4. Alcoholism and Drug Abuse

Disorders associated with alcoholism and other forms of drug abuse can be life threatening. The paramedic must be familiar with the signs, symptoms, and treatment of both syndromes.

### Alcoholism

Alcoholism is the third major health problem in the United States today. The number of alcohol-related deaths is exceeded only by those from cancer and heart disease. There are an estimated 6 to 10 million alcoholics in this country, and alcohol is directly involved in 30,000 deaths and 500,000 injuries due to automobile accidents annually. Furthermore, through its harmful effects on the liver, stomach, pancreas, and central nervous system (CNS), alcoholism decreases the lifespan by 10 to 20 years.

The alcoholic syndrome usually consists of two phases. The first phase is problem drinking. During this phase, the individual uses alcohol frequently to relieve tensions and other emotional difficulties. The second phase is true addiction. In this phase, the individual becomes physically dependent on alcohol, to the extent that not drinking produces major withdrawal symptoms. The diagnosis is the same no matter what type of alcohol the patient drinks: the heavy beer drinker can be an alcoholic just as easily as the patient who drinks too much hard liquor or wine. Frequently, alcoholics are dependent on other drugs as well, particularly sedatives, barbiturates, and tranquilizers.

Alcoholism occurs in all social classes, and only a small percentage of alcoholics are the "skid row" type. Most alcoholics are employed men (only one in four alcoholics is a woman). Most alcoholics do not consider themselves as such and insist that they are only "social drinkers."

However, true alcoholics differ in many ways from social drinkers. Alcoholics usually begin drinking early in the day; they are prone to drinking alone or secretly; and they may periodically go on binges, characterized by heavy drinking over a period of several days or weeks and sometimes accompanied by total or partial loss of memory for that period ("blackout"). For alcoholics, not drinking produces withdrawal symptoms, such as tremulousness, hallucinations, seizures, or delirium tremens (D.T.'s). The D.T.'s are a psychiatric disorder in which the patient loses contact with reality, usually within 24 to 72 hours after the victim's last drink. Symptoms of the D.T.'s include confusion, tremor, wakefulness, and visual hallucinations.

As the alcoholic depends more and more on drinking, his or her performance at work and relationships with friends and family deteriorate. Absences from work, emotional problems, and automobile accidents become more frequent. The alcoholic is prone to the following illnesses and injuries:

- **Subdural hematoma.** Impaired clotting mechanisms and frequent falls render the alcoholic more susceptible to subdural hematoma. Clotting is impaired because alcohol damages the liver and interferes with its synthesis of clotting factors. Subdural hematoma (blood clot in the brain) occurs when blood vessels traveling between the pia mater and the dura mater rupture and bleed into the subdural space. This is dangerous because it increases intracranial pressure and, if not treated, forces the temporal lobe downward. The temporal lobe then compresses the vital centers in the brainstem.
- **Cirrhosis of the liver.** Liver damage may cause cirrhosis of the liver and impair glucose metabolism. Impaired glucose metabolism makes the alcoholic more prone to hypoglycemia.
- **Pancreatitis.** There is a high incidence of pancreatitis among alcoholics. Pancreatitis is inflammation of the pancreas.
- **Upper gastrointestinal hemorrhage.** The alcoholic is prone to major upper gastrointestinal hemorrhage, from gastritis, ulcers, and esophageal varices (dilated esophageal veins).
- **CNS disorders.** CNS disorders occur more frequently in alcoholics. These problems include memory loss, oculomotor (cranial nerve III) damage, peripheral nerve damage, and cerebellar damage.

Due to patient denial and the family's reluctance to discuss the problem, it is often difficult to obtain a history of alcohol dependence. There are clues, however, that may help the paramedic to discover whether a patient is an alcoholic or a problem drinker. These clues include:

- An unexplained history of repeated gastrointestinal problems, especially bleeding.
- The "green tongue syndrome" (this comes from chlorophyll-containing compounds used to disguise the odor of alcohol on the breath).
- Cigarette burns on clothing due to falling asleep with a lit cigarette.
- Chronically flushed face and palms.
- Tremulousness.
- The odor of alcohol on the breath under inappropriate circumstances (e.g., at work or early in the morning).

While it is important to detect evidence of chronic alcoholism or acute intoxication when assessing a patient, it is equally important not to attribute all the patient's symptoms to alcohol until other possible causes are ruled out. A patient's stupor may result from anything, including head trauma, hypoglycemia, and infection. The alcoholic's stupor is no less a threat to life—indeed it may be more of one, due to the patient's depressed condition—than stupor in the sober patient. The alcoholic or intoxicated patient should, therefore, be given the same careful assessment and management that would be given to any other patient.

There are two syndromes directly related to alcoholism, acute intoxication and alcohol withdrawal. The signs of acute alcohol intoxication are similar to those of overdose on other CNS depressants: drowsiness, disordered speech and gait, and erratic behavior. This picture may be precisely mimicked by the diabetic patient in insulin shock; however, you should stay highly suspicious and give glucose. If the patient is not diabetic, glucose will not hurt, and, indeed, many nondiabetic alcoholics also have significant hypoglycemia.

It is quite possible that the patient may have taken both alcohol and sedatives. The patient's pockets and surroundings should be checked for medications that may complicate the diagnosis and treatment. The alcoholic in coma should be treated like any other comatose patient, with attention to the airway plus careful monitoring. In severe intoxication, respiratory depression, cardiac arrhythmias, or shock may occur. These also should be managed as they would be in any other patient.

Alcoholic withdrawal has a wide spectrum of symptoms, ranging from tremulousness, alcoholic hallucinosis, and withdrawal seizures to frank delirium tremens. Tremulousness occurs when the patient is "sobering up" and includes irritability, headache, nausea and vomiting, slowed thought, a fine tremor, and tachycardia. These symptoms may last several days during withdrawal in the chronic alcoholic. Alcoholic hallucinosis occurs within the first 24 hours of withdrawal and consists of auditory or visual hallucinations, without other symptoms of delirium tremens.

Withdrawal seizures may occur in the 12- to 48-hour period following the last drink; they are caused by alkalosis that occurs during this time. Alcohol withdrawal seizures are treated like other seizures, as described in Module VII.

Delirium tremens usually occurs 24 to 72 hours after the patient's last drink, but may occur as long as 7 to 10 days later. The D.T.'s are life-threatening, and characterized by confusion, agitation, sleeplessness, hallucinations, and sympathetic nervous system discharge—fever, tachycardia, sweating, and pupil dilation.

Fluid losses are high during the D.T.'s, due to increased activity, fever, and sweating. Therefore, these patients may become dehydrated. They may also be hypoglycemic and have electrolyte imbalances. Patients with high fevers are more likely to die from delirium tremens. The disorder is fatal in about 10 percent of cases. The paramedic should suspect the D.T.'s in any patient with delirium of unknown cause and should seek an alcohol history for these patients. Field treatment of these patients centers mainly on reassurance. If transportation must be delayed, an IV can be started and the physician consulted about the use of a sedative (Valium).

## Drug Abuse

Drug abuse is defined as the self-administration of a drug, other than alcohol, in a manner that is not medically or socially approved. It is possible to identify patterns of drug abuse, which may be classified under the general heading compulsive drug abuse or drug dependency. The following terms used in this area require definition:

- **Psychological dependence.** Psychological dependence occurs when the effects produced by the drug are necessary to maintain an individual's feeling of well-being. This is also called habituation.
- **Compulsive drug use.** Compulsive drug use implies that the individual is preoccupied with the use and procurement of the drug—as exemplified by heavy smokers who become frantic when they run out of cigarettes.
- **Tolerance.** Tolerance occurs when, after repeated exposure to a drug, the patient needs progressively larger doses to achieve the desired effect.
- **Physical dependence.** Physical dependence exists when drug administration must be continued to prevent withdrawal symptoms.
- **Addiction.** Addiction involves all of the above and is characterized by an overwhelming involvement in the use of the drug.

Drug abuse is not limited to the "younger generation," but occurs in all age groups and social classes. The list of commonly abused substances is a long one, ranging from caffeine and tobacco (nicotine) to over-the-counter sleep medications. In general, abused substances fall into the following major categories:

- Narcotics, such as heroin, morphine, Dilaudid, Demerol, codeine, and propoxyphene (Darvon).
- CNS depressants, such as alcohol, barbiturates, tranquilizers, and antihistamines.
- CNS stimulants, such as amphetamines and cocaine.
- Antidepressants, such as Elavil, Sinequan, and Tofranil.
- Hallucinogens, such as LSD, mescaline, psilocybin, and peyote.

The prevalence of drug abuse prompts certain guidelines. The paramedic should:

- Always ask every patient about the use of medications, whether prescribed or self-administered. It is often useful, when in a patient's home, to check out the medicine cabinet. Be aware that drugs may be contributing to the patient's difficulties.
- Be careful about the drugs you carry in your ambulance. Ideally, they should be in a locked cabinet, especially if you carry morphine or other narcotics.
- When dealing with younger patients who have drug-related problems, maintain an interested, nonjudgmental attitude. Explain that it is important to know about their use of medications in order to help them. Explain also that it is not your job to report them to the authorities.
- Be aware that unexplained stupor, coma, behavioral changes, or seizures may be caused by drugs.

# Unit 5. Poisoning and Overdose

Poisoning and overdose are really two parts of the same problem. In this discussion, however, a distinction is made between the two. Poisoning represents exposure to agents that are harmful in any dosage; overdose represents exposure to high doses of agents that are harmful when taken in excess. The two will be discussed separately, although their principles of management are similar.

## Poisoning

Poisoning is mainly a pediatric problem. Of the 1,000,000 poisonings reported in the United States each year, about 75 percent occur in children under 5, and most are caused by household products. Suicidal and homicidal attempts account for most adult poisonings.

It is beyond the scope of this Manual to provide an encyclopedia of poisons. Detailed information can be obtained from all local poison control centers, which are staffed by experienced people with access to information on more than 250,000 poisonous substances. In any case of poisoning, the hospital should provide the specific antidotes for each agent.

This section provides guidelines for the treatment of poisoning in general and the management of a few common poisonings specifically. For each given case, however, the paramedic should seek advice from the medical director and the local poison control center.

Poisons can enter the body through ingestion, inhalation, surface absorption, or injection. Ingested poisons usually remain in the stomach only a short time, and the stomach absorbs only small amounts. Most absorption takes place after the poison passes into the small intestine. You should suspect poisoning in any patient who presents a sudden onset of unexplained illness, especially an illness characterized by abdominal pain, nausea, vomiting, or CNS problems. Thus management is aimed at trying to rid the body of the poison before it reaches the intestines.

In order to manage a poisoned patient, the paramedic must take a relevant history, including obtaining answers to the following questions:

- **What** was ingested? The poison container and all its remaining contents, the plant, or a sample of what was ingested should be brought to the emergency department. If a plant was ingested, the paramedic must find out what part of the plant (root, leaves, stems, flower, fruit) was actually swallowed. If the patient has vomited, save a sample of the vomitus in a clean, closed container and take it to the hospital with the patient.
- **When** was the substance taken? Decisions about gastric lavage will depend on how much time has passed since then.
- **How much** of the substance was taken?
- Has the patient or bystanders tried to induce **vomiting?** Has anything been given as an antidote?
- Does the patient have a **psychiatric history?** (This is important in determining suicide attempts.)

In addition to the standard observations made in primary and secondary surveys, paramedics should also look for signs characteristic of poisonings by specific substances. Note the skin color. For example, flushed, red, or "cherry red" skin may be indicative of carbon monoxide poisoning. You should also check the patient's breath for the presence of petroleum products, alcohol, or other suggestive odors.

The EMT-P should keep three basic principles in mind when managing the patient who has ingested a poison:

- Maintain the airway by intubating the trachea. *This cannot be overstressed.* The sleepy or comatose patient is in constant danger of aspiration.
- Decide whether to induce vomiting in the patient. As a general rule, if the patient has ingested a poison within the past 3 to 6 hours, the stomach should be emptied, but there are important exceptions. *Never induce vomiting* in:
  —The stuporous or comatose patient.
  —The patient with seizures.
  —The pregnant patient.
  —The patient with possible acute myocardial infarction.
  —The patient who has ingested corrosives (strong acids or alkalis).
  —The patient who has ingested petroleum products (kerosene, gasoline, lighter fluid, furniture polish).
- When in doubt, call for direction.

For practically all other ingested poisons, the paramedic should promptly empty the patient's stomach. Studies have shown that vomiting is the most effective way to empty the stomach of ingested poisons. To empty the patient's stomach in this way, you should:

- Give syrup of Ipecac—15 cc with 2 to 3 glasses of water for a child over 1 year old, and 30 cc with 2 to 3 glasses of water to an adult.
- Place the patient facedown, with the head lower than the hips, to reduce the possibility of the patient's breathing in the vomitus.
- If vomiting does not occur within 20 minutes, repeat the dose of Ipecac once.
- After vomiting stops, give activated charcoal. Mix at least 2 tablespoons of activated charcoal in tap water just before administration, to make a slurry. Children may require some persuasion to drink the mixture, since its appearance is uninviting. A firm, positive approach generally works. Do not give activated charcoal with syrup of Ipecac, because the charcoal will inactivate the syrup of Ipecac. Avoid activated charcoal in suspected cyanide poisoning.

If vomiting cannot be induced, gastric lavage may be necessary. The same contraindications that apply to inducing vomiting also apply to lavage. To perform gastric lavage, the paramedic should:

- Pass a large nasogastric tube into the stomach (use the oral route for younger children and infants, the nasal route for older children and adults).
- Position the patient on the left side, with the face down, to increase drainage and minimize aspiration.
- Aspirate the tube with a large syringe before beginning lavage. Save the contents.
- Instill saline (20 ml for small children, 50 ml for older children or adults) into the stomach through the nasogastric tube. Aspirate the tube and save the first aspirate for lab analysis.
- Repeat lavage until the fluid is clear. At this time, give activated charcoal (at least 3 tablespoons in tap water) through the nasogastric tube, which can then be pinched off and withdrawn. *A nasogastric tube should never be passed in*

*a stuporous or comatose patient unless the airway has first been secured with a cuffed endotracheal tube.* Likewise, a nasogastric tube should never be passed in a patient who may have ingested a substance like acid or lye.

- Start an IV initially with D5W. Draw blood for lab studies.
- Be prepared to manage shock, coma, seizures, or arrhythmias as described in other sections of this Manual.
- Do not give CNS stimulant medications to patients with CNS depression. This has been shown to increase the number of fatalities in such patients.

## Guidelines for the Management of Specific Ingestions

Strong acids include toilet bowl cleaners, rust removers, and phenol. To manage ingestion of these substances, the paramedic should:

- *Never induce vomiting.*
- Give milk of magnesia, milk, egg white, or flour in water in an attempt to neutralize and dilute the acid.
- Start an IV with D5W.

Strong alkalis include drain cleaner, washing soda, ammonia, and household bleach. These substances burn the mouth and esophagus, producing pain and difficulty swallowing. To manage the ingestion of these substances, the paramedic should:

- *Never induce vomiting.*
- Give diluted citrus fruit juice or equal parts of vinegar and water (in addition, 50 ml of olive oil may ease the pain).
- Start an IV with D5W.

Kerosene, lighter fluid, gasoline, furniture polish, and turpentine are all petroleum products. Patients who ingest these substances characteristically show signs of respiratory distress, including coughing, choking, pulmonary edema, and sometimes, cyanosis. They may complain of severe abdominal pain. In addition, they are prone to CNS symptoms, ranging from irritability to convulsions and coma. Hypoglycemia is common. Cardiac arrhythmias also have been reported. To manage patients who have ingested petroleum products, the paramedic should:

- *Never induce vomiting* unless a very large volume (more than 50 ml) of kerosene or gasoline has been drunk. In these cases, potential toxicity to the brain and heart requires that the poison be eliminated. First, protect the airway with a cuffed endotracheal tube—this is not easy if the patient is awake—and then perform gastric lavage through a nasogastric tube. These maneuvers should be carried out in the emergency department unless the hospital is far away.
- Give 100 percent oxygen with good humidification.
- Start an IV with D5W. Give 25 g of D5W by IV push if coma or seizures are present.
- Monitor cardiac rhythm.
- Anticipate massive secretions, and have suction ready.

Methyl alcohol (methanol, wood alcohol) is present in paints, paint removers, varnishes, and antifreeze. It is sometimes used as a substitute for ethyl alcohol (ethanol) by desperate or unenlightened alcoholics. It causes severe acidosis and blindness. The breath of a patient who has drunk methanol will smell like alcohol. The patient will usually be hyperpneic and hypotensive, and may be in shock. To manage these patients, the paramedic should:

- Induce vomiting if the patient is conscious and give 1 ounce of 80 proof whiskey every hour (the dose must be reduced in children). Ethanol—the alcohol one normally drinks—inhibits methanol metabolism.
- Start an IV with D5W. Give an ampule (50 milliequivalents) of biocarbonate.
- Monitor cardiac rhythm.
- Administer oxygen.
- Treat as usual for comatose patients if the patient is unconscious.

Cyanide poisoning, while relatively uncommon, is dangerous and unique enough to deserve special mention. Cyanide poisoning may occur through ingestion (bitter almonds, seeds of cherries, apples, pears, latrile, and possibly apricots), inhalation (gases generated in blast furnaces or fumigants), or absorption through the skin. When the exposure is massive, fatal respiratory arrest may occur with little warning.

On physical examination, the patient with cyanide poisoning may be confused or stuporous. The classic odor of bitter almonds on the patient's breath suggests cyanide poisoning but is not diagnostic. The breathing is usually rapid and labored at first, but may become slow and gasping. The pulse is usually thready and rapid. Vomiting, coma, and seizures frequently occur. The patient's venous blood (and sometimes the patient) may be bright red—cyanosis is rare and occurs chiefly at the end. Treatment is supportive and is aimed at displacing cyanide from the cells, where it interferes with those metabolic processes that require oxygen. To manage the patient with cyanide poisoning, the paramedic should:

- Establish an airway.
- Administer 100 percent oxygen. Assist ventilation if necessary.
- If a commercially available cyanide antidote kit is available, follow the instructions supplied with

the kit. If it is not available, break perles of amyl nitrite into a sponge or handkerchief and hold them over the patient's nose for about 20 to 30 seconds every minute. Since amyl nitrite may cause hypotension, keep the patient lying down with the legs elevated.

- Start an IV with D5W to keep open.
- Monitor cardiac rhythm.

The cardinal rule in managing a patient with a suspected toxic inhalation of inhaled poison is to *get the patient away from the gaseous poison* and optimize ventilation.

Carbon monoxide causes more poisoning deaths than any other substance. It is produced during the incomplete burning of organic fuels, most commonly in automobiles or home heating devices. Because home heating devices produce carbon monoxide, this poisoning occurs more frequently in the winter, when it can accumulate when a flue or ventilating system becomes blocked. However, at least half of all successful adult suicides are caused by carbon monoxide poisoning, and these may occur at any time of the year. An automobile in a small closed garage can produce a lethal concentration of carbon monoxide in 15 to 30 minutes. Carbon monoxide is a colorless, odorless, tasteless gas. These characteristics make the detection of carbon monoxide in the air difficult and thus increase its dangerousness. Usually the victim does not realize what is happening until it is too late.

Carbon monoxide is toxic because it binds to hemoglobin in red blood cells and displaces oxygen, thereby preventing the transportation of oxygen to the tissues by the red blood cells. The result is suffocation at the cellular level. The level of carbon monoxide in the blood does not need to be high for poisoning to occur, because this gas has an affinity for hemoglobin that is 200 times stronger than oxygen's. Because the blood's ability to deliver oxygen is reduced, any condition that increases the need for oxygen—such as fever or physical exertion—increases the severity of carbon monoxide poisoning. Carbon monoxide poisoning is also more severe in children, since their resting metabolic rate is higher than that of adults.

The warning symptoms of carbon monoxide poisoning include a sense of pressure in the head and a roaring in the ears. With acute poisoning, the patient is confused and unable to think clearly. The patient may appear drunk and often vomits and becomes incontinent; convulsions and coma then follow.

Physical examination of such patients will reveal bounding pulses, dilated pupils, and cyanosis or pallor. A cherry-red color of the lips, although classically described, is rarely seen. In the comatose patient, rales—indicating pulmonary edema—may be heard. Symptoms vary greatly in different individuals with the same carbon monoxide exposure. Therefore, paramedics should consider carbon monoxide poisoning whenever they are confronted with a group of people with different symptoms who were sharing accommodations when their symptoms started.

Treatment of carbon monoxide poisoning is aimed at providing maximal oxygenation. To accomplish this the paramedic should:

- Remove the patient from the exposure site.
- Give 100 percent oxygen by mask.
- Support respirations with a bag-valve mask if there is respiratory depression.
- Treat coma, as outlined in Module VII.
- Move the patient rapidly to a hospital, where high oxygen concentrations can be delivered more effectively.

Freons are used as refrigerants and as propellants in many aerosols. Some individuals also use freons for obtaining a "high" (as intoxicants). Freons produce marked cardiac toxicity that is often fatal. Therefore, managing the patient with freon exposure involves anticipating arrythmias. You should:

- Remove the patient from contact with the freon.
- Administer oxygen.
- Start an IV with D5W and have lidocaine ready.
- Monitor cardiac rhythm

Glue and other solvents (cleaning fluid, paint thinner, gasoline, nail polish remover) are also sniffed by the young in search of "highs." Patients using these solvents often show symptoms like those of alcohol intoxication. They may also experience hallucinations and extreme panic, similar to that sometimes experienced by patients intoxicated with LSD. Treatment is largely supportive. The paramedic should get the patient away from the inhalant, administer oxygen, and offer reassurance if the patient is panicky.

Poisons—for example, organic phosphates or cyanide—can also be absorbed through the skin. Treatment for absorbed poisons involves removing the substance from the skin. The area should be flushed copiously with a steady stream of water. If dry lime is the poison, the paramedic should brush off the excess before flushing. Phenol should be flushed off with alcohol, in which it is soluble, rather than water, if large quantities of alcohol are available, but if alcohol is not available, use water.

Do not waste time removing contaminated clothing or shoes until you have been flushing for several minutes; then you can remove contaminated clothing and continue flushing. Do not use specific antidotes until after the skin has been copiously irrigated with water. After repeated flushing and removal of contaminated clothing, areas exposed to acids can be washed with soap, and areas exposed to alkalis can be rinsed with diluted lemon juice or vinegar. Eyes should be irrigated *only* with water; other antidotes must never be used in the eyes.

Poisons can be injected by stings or bites from insects, spiders, or snakes. One effect of bee stings, anaphylaxis, was covered earlier in this chapter. Other effects of bites and stings from insects, spiders, and snakes are discussed below.

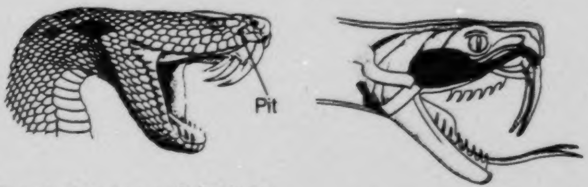
Injected poisons usually produce the following complex of symptoms:

- Pain and tenderness at the injection site.
- Swelling.
- Systemic reactions, ranging from fever and delirium to cardiorespiratory failure.

In general, treating patients with poisonous injections involves preventing or delaying absorption of the injected poison and supporting vital functions.

To treat snakebites you should keep in mind that most snakes are not poisonous. In this country, poisonous snakes include only pit vipers (found everywhere except the extreme Northeast) and coral snakes (found chiefly in the midsouthern, southwestern and western States). Alaska, Hawaii, and Maine are free of venomous snakes.

Pit vipers include rattlesnakes, copperheads, and cottonmouth water moccasins. The rattlesnake is the most common. The most impressive rattlesnake is the diamondback, which reaches a length of 8 feet and a weight of 30 pounds—a formidable adversary. All pit vipers have triangular heads that are wider than their necks. They also have pits between their eyes and nostrils (hence the name); these pits look like an extra pair of nostrils (see Fig. 10.1).



The pit viper has a pit between the eye and nostril.

The snake's venom flows through the fang.

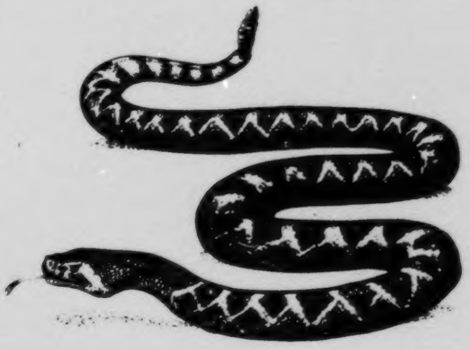


**Figure 1. Pit Viper**

Pit vipers have erectile fangs that are 15 mm long on the average. These fangs are like hypodermic needles—when the skin is punctured, the poison is injected through the fangs.

Coral snakes are small and brightly colored, with bands of red, yellow, and black (see Fig. 10.2). A black nose with red and yellow stripes that are never adjacent to each other distinguish the coral snake from its two imitators (scarlet snake and scarlet king snake).

Only about 10 percent of coral snake bites are fatal. Fatal bites occur only when the snake is at least 20 inches long, and either bites the victim in more than one place or hangs onto the victim for a long time.

The venoms of most species have diversified mixtures of several toxic products. While the exact role of the different toxic components is not completely known, the venom of a given species is usually predominantly neurotoxic or necrotizing. The type of venom injected will determine the symptoms.

Pit viper venom is necrotizing, causing local tissue death, destruction of red blood cells, and hemorrhage. It acts immediately, causing instantaneous pain and progressive local edema, with rapid development of ecchymosis. Without treatment, the swelling spreads and may soon involve the entire extremity. As the venom is absorbed, systemic symptoms may begin, often within 10 to 15 minutes. Such symptoms include:

- Bloody urine and gastrointestinal bleeding caused by internal hemorrhage.
- Muscle twitching.
- Slurred speech.
- Nausea and vomiting.
- Fainting and coma.
- Sweating.
- Tachycardia and hypotension.
- Shallow respirations, progressing to respiratory failure.

Yellow vision and numbness at the injection site or around the mouth, tongue, or scalp are ominous signs, often heralding generalized paralysis and respiratory failure.

All poisonous snake venoms contain varieties of the same type of toxin. The pit viper venom contains more hematoxins and spreading factors, such as hyaluronidase and lecithinase, whereas coral snake venom contains mostly neurotoxins.

The aim of treatment is to slow venom absorption. To accomplish this, the paramedic should:

- Where applicable, remove all rings and bracelets on the affected extremity and apply constriction bands (tourniquets) about 2 inches above and 2 inches below the injection site. These should be tight enough to occlude venous return, but not so tight as to shut off arterial flow. Check to make sure there is still a pulse below the bands. Release the bands for about 90 seconds every 10 minutes, moving them to stay a few inches ahead of advancing edema. Constriction bands must be applied within 30 minutes following the bite or they will not help.

- Apply ice bags to the injection site to produce vasoconstriction, decrease swelling, and slow the action of harmful enzymes contained in the venom. If ice is not available, you may immerse the extremity in a cold running stream.
- Make an incision through each puncture wound along the long axis of the limb. The incisions should be ¼ inch deep and about ½ inch long. Then apply suction to these incisions for at least 1 hour, using any available means. If no other method of applying suction is available, suck on the wound and spit out the aspirated material.
- Splint the bitten extremity just as if it were broken, and keep it still. Never allow the patient to walk or run. Activity hastens venom absorption.
- Discourage the patient from drinking alcohol, since this may aggravate CNS depression.
- Start an IV of Ringer's solution in the uninvolved arm.
- Manage shock and coma as outlined elsewhere in this Manual.
- Transport the patient to a hospital where antivenin can be administered and further surgical treatment performed.
- Keep the patient supine throughout treatment.

The main idea of treatment is to:

- Reduce the spreading of toxin by decreasing cardiac return as much as possible. Along with using the constriction bands encouraging patients to rest and reassuring them can accomplish this.
- Remove the venom by longitudinal incisions and suction. After the patient arrives at the hospital, doctors can cut out all subcutaneous tissue that contains pink-tinged hemorrhage, indicating presence of venom, and apply a skin graft.

The venom of the coral snake is neurotoxic, with death resulting from respiratory paralysis caused by damage to brain centers and the neuromuscular junction. The coral snake bite causes little pain and local swelling. The patient usually has multiple fang marks. Within 10 to 15 minutes, the following symptoms may be observed:

- Numbness and weakness in the region of the bite.
- Ataxia.
- Laryngeal and tongue paralysis.
- Slurred speech.
- Excessive salivation.

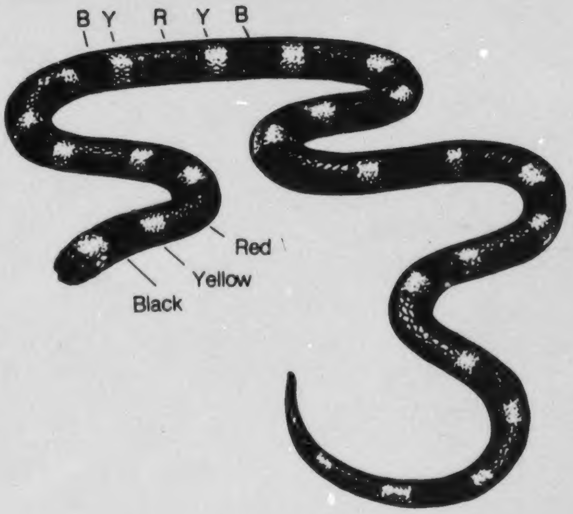


**Figure 2. Coral Snake**

- Ptosis (drooping of the upper eyelid).
- Dilated pupils.
- Loss of consciousness, with respiratory failure and seizures.

Management of coral snake bites is similar to management of pit viper bites. Coral snake bites are serious, even though they produce few immediate effects. To treat the patient who has been bitten by a coral snake, the paramedic should:

- Remove the patient's rings and bracelets, apply constricting bands, and keep the bitten extremity still.
- Wash the bitten area well to remove venom that may have splashed on the surface.
- Apply ice or cold water to the bitten area.
- Make a ¼-inch-deep by ½-inch-long incision through each puncture wound along the long axis of the limb. Apply suction to these incisions for at least 1 hour.
- Splint the bitten extremity as if it were broken. Do not allow the patient to walk or run.
- Start an IV of Ringer's solution in the uninvolved arm.
- Transport the patient to the hospital, where antivenin can be administered.

Insects and spiders also inject venoms. These venoms can be fatal if the victim is allergic to the venom or if a large number of bites are received. Different types of insect and spider bites and stings will be discussed below. In all cases, however, the paramedic should try to bring a sample insect or spider to the hospital so that it can be identified.

The major problems with all insect envenomations are allergic reactions ranging in severity from urticaria to full-blown anaphylactic shock. Any patient displaying a rash should receive parenteral Benadryl (diphenhydramine hydrochloride) immediately. Keep a close eye for progressive symptoms leading to laryngospasms and bronchospasms, as epinephrine may be necessary if Benadryl is ineffective.

Bees, wasps, and hornets sting their victims. Honeybees leave their stinger attached to the victim. Wasps and hornets do not leave their stingers and can sting repeatedly. Bee, wasp, and hornet venoms contain histamine and other toxic substances.

Before treating the bee, wasp, or hornet sting, the paramedic should determine whether the stinger is still attached to the victim. If it is, the paramedic should remove it, without squeezing, since squeezing will inject the venom further. Scrape the stinger away with a pocketknife and then wash the stung area well. Next, apply ice to the area and elevate it if it is on an extremity. Be prepared to treat anaphylaxis as described earlier, especially if the patient has a history of allergies.

Fire ants can also produce serious reactions. At the puncture site, the fire ant bite causes stinging pain, followed by local edema (a wheal). The wheal progresses to form a vesicle (small blister) and then a pustule (a pus-containing lesion). Fire ant bites can cause severe systemic and allergic reactions. There is no specific treatment for the fire ant bite itself. Paramedics should treat systemic and allergic reactions as described for beestings.

Ticks attach to a host and release toxins. One toxin sometimes causes tick paralysis. Tick paralysis is a flaccid paralysis, or paralysis with decreased muscle tone. The paralysis starts at the feet, with pain, numbness, and tingling. The feet and legs then become paralyzed, and the paralysis ascends upward. When the respiratory muscles become paralyzed, the patient can die of respiratory failure.

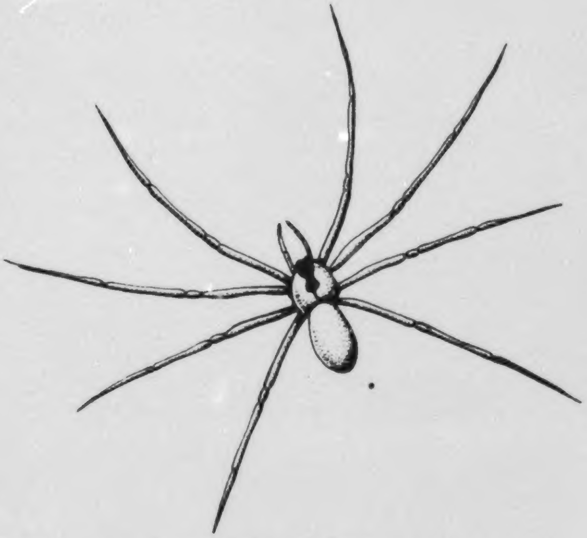


**Figure 3. Brown Recluse Spider**

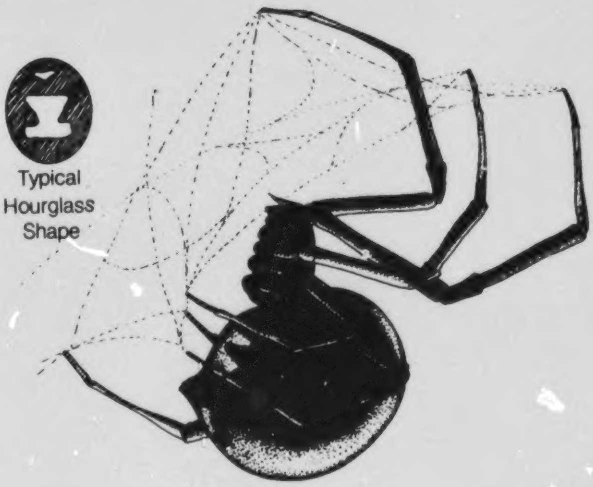


**Figure 4. Black Widow Spider**

Tick paralysis will disappear when the tick is removed. The paramedic should first search the patient's body for the tick. When the tick is located, gasoline, ether, or a hot match should be applied to it; this will cause the tick to release itself. Respiratory failure due to tick paralysis should be treated before the paramedic searches for and removes the tick.

Two types of spiders—the brown recluse spider and the black widow spider—are dangerous to humans. Brown recluse spiders average 12 mm in length and 6 mm in width (see Fig. 10.3). They have six eyes in three pairs and a violin-shaped marking that extends backward from the eyes.

Local reactions to brown recluse spider bites begin after 2 to 8 hours and include redness, pain, and blistering. These reactions progress to tissue necrosis. Systemic reactions include chills, fever, nausea and vomiting, joint pain, and bleeding disorders. There is no specific treatment for brown recluse spider bites, although some physicians surgically remove the bitten area to prevent further toxin absorption.

The female black widow spider averages 15 mm in length and 10 mm in width. It is completely black, except for an orange or red hourglass marking on the underside of its abdomen (see Fig. 10.4).

When the female black widow spider bites, it causes sharp local pain followed by numbness. If the bite is on the leg, the abdominal muscles will soon become rigid and painful. If the bite is on the arm, pain and rigidity will develop in the chest, back, and shoulder muscles. The patient's temperature and blood pressure may also rise.

To treat a female black widow spider bite, the paramedic should apply ice to slow toxin absorption. The physician may order muscle relaxants such as diazepam (Valium) and calcium gluconate to reduce muscle rigidity. Antivenin may be administered after the patient has reached the hospital. Robaxin will act against the muscle spasm of a black widow spider bite for as long as 48 to 72 hours.

Stings from some types of scorpion can be fatal. The scorpion has two anterior clawed legs, four pairs of walking legs, and a long tail with a stinger at the end.

When a scorpion with a lethal type of venom stings, the patient will experience sharp local pain followed by numbness. The patient then becomes drowsy, and the mouth, nose, and throat begin to itch. Speech becomes slurred, and the patient develops muscle spasms, nausea and vomiting, and convulsions.

Treatment for scorpion stings is similar to that for snakebite. The paramedic should:

- Apply a tourniquet above the sting.
- Pack the area with ice and leave the ice on for 2 hours.
- Never use morphine or codeine, as they will increase the venom's toxic effects.

After the patient reaches the hospital, specific antivenin may be administered.

Venomous organisms live in the water as well as on land. There are differences, however, between the stings and bites of aquatic organisms and those of land organisms. First, the venom of aquatic organisms may produce more extensive tissue damage. Tissue injuries produced by aquatic organisms should be treated as soft-tissue injuries (Chap. 8). Second, venoms of aquatic organisms are destroyed by heat. Therefore, heat, rather than ice, should be applied to stings and bites of venomous aquatic organisms. To treat these injuries, the paramedic should:

- Apply a tourniquet above the sting or bite.
- Apply heat and maintain the injured area at a temperature of 110° to 114°F for 30 minutes.
- Apply heat for another 30 minutes if symptoms recur.

Aquatic organisms inject venom by biting, stinging, or using spines. Octopuses and sea snakes inject venom when they bite. These bites produce few local effects. Systemic symptoms develop in 2 to 6 hours and include muscle stiffness, paralysis, and respiratory arrest. To treat these bites, the paramedic should apply a tourniquet, use local heat, and control shock. Be prepared to treat respiratory failure and cardiac arrest.

Animals with special stinging capsules, or nematocysts, include jellyfish, Portuguese men-of-war (see Fig. 10.5), anemones, and corals. Nematocysts contain coiled stingers, which fire and penetrate the victim's skin to inject venom. Venom from these organisms can cause anaphylaxis in an allergic victim or can cause death directly.

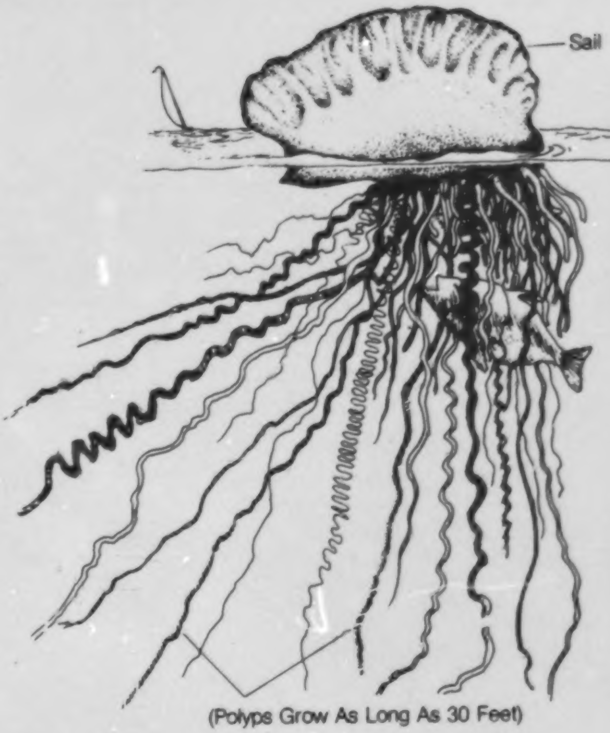

Sail
(Polyps Grow As Long As 30 Feet)

**Figure 5. Portuguese Man-of-War**

If the nematocyst contains lethal venom, the victim experiences severe pain, throbbing headache, cramps, paralysis, and severe respiratory distress. To treat nematocyst wounds, the paramedic should:

- Apply a tourniquet above the wound. These wounds often contain nematocysts that have not fired yet.
- Pour isopropyl alcohol over the wound and leave it on for 6 to 8 minutes. This will inactivate nematocysts that have not fired.
- Apply a concentrated solution of sodium bicarbonate to the wound and let it dry. This will neutralize the acidic venom.

Animals that use spines to inject venom include the stingray, sea urchin, catfish, and scorpionfish. Stingray spines cause extensive tissue damage, which may require surgical treatment. These wounds can cause sharp, intermittent local pain. Systemic symptoms can include fainting, weakness, nausea and vomiting, nervousness, tremor, arrhythmias, and dyspnea. To treat stingray wounds, the paramedic should apply heat and flush with normal saline to remove the toxin.

Scorpionfish wounds produce immediate pain and swelling, which may involve the entire limb. In addition, the patient may develop shock, pulmonary edema, or arrhythmias. Scorpionfish wounds should be treated with local heat and flushed with normal saline. After the patient reaches the hospital, specific antivenin may be administered.

Sea urchin wounds can cause numbness, paralysis, and respiratory distress in addition to local pain, redness, and swelling. Sea urchin wounds should be treated with local heat. The paramedic should also be prepared to treat respiratory distress in patients stung by sea urchins.

## Overdose

Before working with overdosed patients, the paramedic should become familiar with the vocabulary of drug users. The list presented in this *Manual* (see box) is not exhaustive, but is instead a guide to street slang, which varies from community to community and changes rapidly. Therefore, it is wise for you to keep a glossary of terms currently used in your community.

Obtaining a history from a patient who has taken an overdose is similar to taking a history from a poisoned patient. You should ask the following questions:

- What was taken? The bottle and all its contents should be brought to the emergency department. Its label may help identify the drug, and the number of pills remaining may give a clue to how much was ingested.
- When was it taken?
- How much was taken?
- Was anything else taken (other drugs or alcohol)? Particularly among today's drug culture, overdoses are rarely "pure," and usually represent a combination of agents.
- What has the patient or bystanders done to try to correct the situation? Has vomiting been induced? Street resuscitation procedures are frequently as dangerous as the overdose itself, and exactly what has been done for the patient is very important. The most common form of street resuscitation is "stimulation"—cold showers, vigorous slapping, and so forth. Check for broken teeth, blood in the mouth, or other signs of injury. If the patient has a barbiturate overdose, the patient's friends may have tried to reverse this by giving the patient speed (Methedrine or Dexedrine). There is also a myth prevalent on the streets that salt or milk given intravenously will reverse an overdose. In fact, salt may cause pulmonary edema, and milk can induce lipid pneumonia. All of these street remedies will complicate the picture, so you should learn as much as possible about what has been done.

### Glossary of Street Terms Related to Drug Use

Narcotics

- Heroin: horse, Hary, smack, stuff, doogie, oil, boy.
- Morphine: unkie, Miss Emma, hard stuff.

Depressants ("downers")

- Phenobarbital (Nembutal): yellow jackets, yellow membies.
- Amytal: blue devils, blue birds, blue heaven.
  —Seconal: red birds, red devils, pinks.
  —Chloral hydrate—Mickey Finn, Mickey, Peter
- Phencyclidine (PCP): angel dust.
- Quaalude: soapers.

Stimulants ("uppers")

- Benzedrine (amphetamine): bennie, benzies, peaches, roses, hearts, cartwheels.
- Dexedrine: hearts, oranges, dexies, footballs.
- Methedrine: speed, bomita.
- Cocaine: coke, "c," Corine, Carrie, cholly, happy dust, heaven dust, snow, stardust, girl, Bernice Burese, flake, gold dust.

Hallucinogens

- Marijuana: pot, tea, weed, Mary Jane, grass, love week, reefer, joint, hay, hash, joy smoke, stinkweed.
- LSD: acid, cubes, sugar, pearly gates, heavenly blue, royal blue, wedding bells.

The following terms are also used in relation to drugs:

- Blank: low-grade narcotics.
- Burned: received poor quality or counterfeit drugs.
- Coasting: under the influence of drugs.
- Cold turkey: sudden withdrawal of narcotics.
- Cut: dilute drugs.
- Dynamite: high-grade heroin.
- Joy pop: inject narcotics regularly.
- Layout: outfit employed by opium user.
- Lemonade: poor-quality heroin.
- On the nod: drowsy from narcotics.
- Panic: shortage of available narcotics.
- Quill: matchbook for sniffing cocaine.
- Reader: prescription order.
- Reader with tail: forged prescription order.
- Shooting gallery: place where addicts inject drugs.
- Snorting: inhaling drugs.
- Works: equipment for injection drugs.

To manage the overdosed patient:

- Maintain an airway. Intubate the comatose patient.
- Administer oxygen.
- Induce vomiting, as outlined previously, if the drug was taken by mouth. There are, however, important exceptions. *Never induce vomiting in:*
  —The stuporous or comatose patient.
  —The patient who has ingested phenothiazines (a class of drugs, including Thorazine, used as tran-

quilizers). Phenothiazines prevent vomiting, so the patient will end up with a stomach dangerously full of syrup of Ipecac and water if attempts are made to induce vomiting.

- Start an IV with D5W.
- Monitor cardiac rhythm.

## Guidelines for the Management of Specific Overdoses

This section discusses managing overdoses from five different agents or types of agents. The paramedic should be able to recognize and manage patients who have overdosed on narcotics, sedatives or depressants, amphetamines, hallucinogens, and aspirin.

### NARCOTICS OVERDOSE

The narcotic drugs include heroin, morphine, Dilaudid, methadone, codeine, Demerol, and Darvon. These drugs and their legal uses are described in Module IV. When narcotics are taken in excess, they cause marked respiratory depression. This is shown initially by slow, deep breathing, but leads rapidly to apnea. Narcotic overdose also causes hypotension, stupor, and coma. The pupils characteristically become pinpoint, but this sign may be masked if the patient has overdosed on a combination of drugs.

The paramedic should strongly suspect narcotic overdose in any young patient found in an unexplained coma, especially if there are needle tracks along the veins of the arms or elsewhere. Cigarette burns on the chest are also seen occasionally among these patients; these occur when the patient "nods out" (loses consciousness) while smoking.

Heroin overdose tends to occur in small epidemics. Heroin is sold on the street in an impure form. When a more concentrated supply of the drug reaches the street, users can miscalculate their doses and take more than they had intended. When paramedics encounter one patient with heroin overdose, they are likely to encounter others the same day.

Treating narcotic overdose follows the same principles used for comatose patients. You should:

- Maintain an airway; intubate if protective reflexes are lost.
- Administer oxygen. Assist ventilation as needed.
- Administer 50 ml of D5W IV push.
- Give Narcan if the patient fails to respond to improved ventilation and glucose or if there is reason to suspect narcotic overdose. To administer Narcan:
  —Draw up the contents of one ampule (0.4 mg) into a 10 ml syringe; fill the rest of the syringe with D5W from the IV bottle.
  —Inject the mixture very slowly and stop the injection as soon as respiration begins to improve.
- If there is no response, inject physostigmine 0.5 to 2.0 mg IV slowly. This will counteract tricyclate overdose. Keep in mind that frequently more than one type of drug has been taken.

### SEDATIVE/DEPRESSANT DRUGS OVERDOSE

Barbiturates are among the most abused drugs in the United States today. Furthermore, they are used in more drug-related suicide attempts than any other drug.

The effects, indications, and contraindications of phenobarbital—a representative barbiturate—are described in Chapter 4. Barbiturate effects also closely resemble the effects of diazepam (Valium), also described in Module IV.

The chronic barbiturate abuser is characteristically lethargic, disheveled, and frequently nodding off to sleep. The barbiturate abuser may be taking enormous doses to maintain a habit; therefore, a reduction in daily doses can lead to a dangerous state of withdrawal.

Diagnosing acute barbiturate poisoning may be difficult. The patient who is contemplating suicide may have large supplies of several drugs, and it may be difficult to determine which drug(s) the comatose patient has taken. Further, patients may make suicide attempts with barbiturates while also consuming large amounts of alcohol, so that the odor of alcohol on the patient's breath can further confuse the diagnosis. The paramedic will often have to rely on circumstantial evidence (e.g., empty medicine bottles, the characteristic color of tablets in the mouth, or gastric contents) to diagnose barbiturate overdose.

Acute barbiturate poisoning affects mainly the CNS and the cardiovascular system. Signs and symptoms of moderate overdose resemble those of alcohol intoxication.

In severe overdose, the patient is deeply comatose. The pupils may be constricted early in the course, but later become fixed and dilated. (It is important for the paramedic to remember this sign during resuscitation efforts, because fixed and dilated pupils do not have the same significance in barbiturate overdose as in ordinary cardiac arrest.) Respiration is affected early and becomes very shallow, with resultant hypoventilation and respiratory acidosis. Cheyne-Stokes breathing can occur. Aspiration and consequent pneumonia are also common. Blood pressure falls and the patient may develop a typical shock syndrome, with weak, rapid pulse and cold, clammy skin.

Treatment of barbiturate overdose also follows the principles of treatment used for the comatose patient. The paramedic should:

- Maintain an airway. If the patient is deeply comatose, intubate.
- Administer oxygen. Assist ventilation as required.
- Start an IV with normal saline or Plasmanate and administer at a rate sufficient to maintain blood pressure. If the patient is in shock, consult the

physician about use of the Military Anti-Shock Trousers (MAST).

- Consult the physician regarding possible administration of sodium bicarbonate to alkalinize the urine (to promote excretion of some barbiturates).
- Monitor cardiac rhythm.
- Avoid giving stimulants, such as coffee or intravenous stimulant medications. These increase the complication rate following barbiturate overdose.

## AMPHETAMINE OVERDOSE

Amphetamines—such as Dexedrine and Methedrine—are frequently abused. These drugs stimulate the reticular activating system in the CNS and produce wakefulness.

The amphetamine abuser who has taken quantities of the drug over a period of time displays excitement, loss of appetite, tachycardia, hypertension, sweating, dilated pupils, and tremors. This patient may demonstrate frank amphetamine psychosis as well, with paranoia and hallucinations. The patient may also be violent, and the paramedic should be prepared for this reaction.

In most cases, the drug will wear off and the user will "crash." The patient will then go into a prolonged sleep, followed by a period of extreme hunger and depression. Field treatment of these patients consists primarily of reassuring them. If patients are agitated, paramedics should first ensure their own safety and then attempt to calm the patients down. To best manage these patients, paramedics may need to do one or more of the following:

- Determine whether the patient is violent, and summon police assistance if needed.
- Talk to frightened or agitated patients calmly and reassuringly.
- Provide the patient with a place to "crash." The hospital is often not a very good place for this. A quiet room in the house of a reliable friend, where concerned people will be available to reassure the patient, may be better. Consult the medical director to help decide whether to bring the patient to the hospital.
- Determine whether hospitalization will be necessary. If the blood pressure is significantly elevated, if arrhythmias are present, or if the patient is entirely out of control, hospitalization is required. Use police assistance, if needed, to bring the patient to the hospital.

## OVERDOSE AND TOXIC REACTION TO HALLUCINOGENS

The clinical picture of LSD intoxication includes excitement, panic, hallucinations (usually visual), unusual body sensations, and often psychotic reactions. Most authorities now advocate the "talking down" approach in dealing with these patients, avoiding needless and sedative drugs as much as possible. The paramedic should try to get the patient to a quiet place, away from crowds and noise. The emergency department atmosphere is far from ideal in this respect, and it is often better if you can arrange to have the patient looked after by a responsible friend. It is especially important that you deal with the patient in a calm, understanding manner.

Accidental ingestion of LSD by children or infants is not physically dangerous, but the child may experience the same frightening sensations. The best treatment for such children is simply to have someone fondle and play with them for several hours. In most cases, the children will respond readily to close attention and physical contact.

## ASPIRIN OVERDOSE

Aspirin (salicylate) intoxication is primarily a pediatric problem and is one of the most frequent overdoses in children. Adults can also overdose on aspirin, either accidentally or in suicide attempts.

Salicylate is an acid, and causes profound metabolic acidosis. (Review metabolic acidosis in Module IV.) The patient tries to compensate for the metabolic acidosis, with its excess carbon dioxide, by hyperventilating. As time passes, however, the patient tires and respirations become shallower. Signs and symptoms of salicylate intoxication include:

- Hyperpnea, tachypnea.
- Fever and sweating.
- Vomiting.
- Dehydration, sometimes so severe that it causes shock.
- Convulsions.
- Coma.

Aspirin overdose should be suspected in any child with unexplained rapid respirations. You should search for the bottle to help confirm this.

Management is aimed at eliminating ingested aspirin from the stomach and supporting vital functions. To do this, the paramedic should:

- Induce vomiting with syrup of Ipecac, if the patient is conscious.
- After vomiting stops, give at least 2 tablespoons of activated charcoal mixed as a slurry in tap water.
- Start an IV with D5W. Consult the physician as to IV rate, which will vary according to patient's age, weight, and vital signs.
- Have bicarbonate and diazepam (Valium) on hand.
- If the patient's temperature is elevated above 104°F, sponge the body with cool tap water.

## Unit 6. Acute Abdomen

This unit deals with a variety of disorders that cause abdominal pain. For the most part, it will not be either feasible or useful to distinguish among the many causes of the so-called acute abdomen since, in general, field management will be similar regardless of the cause. However, you should have a general idea of the types of disorders that may be present with abdominal pain and should know which of these may progress to life-threatening situations.

The abdominal cavity is contained by the diaphragm above, the pelvis below, the spine in back, and the muscular abdominal wall in front. It contains the major organs of digestion, excretion, and, in the female, reproduction. The kidneys lie immediately behind the abdominal cavity in the retroperitoneal space. The abdominal cavity is lined by a smooth membranous layer called the peritoneum, from which the abdominal cavity derives the other name it is sometimes called, the peritoneal cavity.

The abdominal cavity contains blood vessels, solid organs, and hollow organs. The aorta and the inferior vena cava are the major blood vessels traversing the abdomen. They lie along the posterior wall of the abdominal cavity, just in front of the spine.

The solid organs of the abdomen and retroperitoneal space include the liver, spleen, pancreas, and kidneys. The liver lies just beneath the diaphragm, predominantly on the right side (right upper quadrant); it is a highly vascular and fragile organ which can be easily lacerated by crushing injuries to the abdomen or lower chest, such as those sustained in steering wheel injury.

The spleen, lying in the upper left quadrant, is also a very vascular and fragile organ. Splenic rupture from trauma may result in rapid bleeding and death. (Patients with fractures involving the 10th to 12th ribs on the left side are particularly likely to have splenic damage.)

The pancreas is a somewhat flat organ lying crosswise in the left upper quadrant of the retroperitoneal area. The pancreas produces powerful digestive enzymes, and if it is injured or diseased, these enzymes can spill over into the peritoneal cavity, causing inflammation (peritonitis) and severe pain.

The kidneys lie in the retroperitoneal space at about the level of the 12th thoracic to 2d lumbar vertebrae. Blunt trauma to the abdomen or back can injure the kidneys.

The hollow organs of the abdomen include the stomach, intestines, gall bladder, and urinary bladder. The stomach lies just beneath the diaphragm, somewhat over to the left side; the region that the stomach occupies is commonly referred to as the epigastrium.

The intestines occupy nearly the whole of the peritoneal cavity. The small intestine consists of the duodenum, the jejunum, and the ileum. The duodenum is directly attached to the stomach and is frequently the site of ulcers. Together, the three parts of the small intestine measure about 24 feet and are richly supplied with arteries and veins. These vessels are susceptible to injury when there is trauma to the abdomen and can bleed profusely.

The large intestine consists of the colon and rectum. The colon is about 5 feet long and passes up, across, and then down the abdominal cavity (ascending, transverse, and descending segments). At the colon's lower end, near where it joins with the ileum, there is a small, wormlike appendage called the appendix which lies in the right lower quadrant and is susceptible to an inflammation known as appendicitis.

The gall bladder, which concentrates and stores the bile produced in the liver, is located in the right upper quadrant. Obstruction of the bile ducts or inflammation of the gall bladder itself (cholescystitis) may produce severe right upper quadrant pain.

The urinary bladder lies just behind the pubic bone in the pelvis; it may become damaged or disrupted by blunt trauma to the abdomen or by pelvic fracture. A full, distended bladder is much more susceptible to such injury than one that has recently been emptied.

As a general rule, injury to solid organs results in hemorrhage, and injury to hollow organs results in spillage of their contents, with consequent peritonitis. Table 10.3 lists the organs found in each of the quadrants of the abdominal cavity.

The patient with an acute abdomen generally has abdominal pain. To assess the implications of the pain, the paramedic should determine the following:

- Location of the pain. Certain organs, like the stomach and duodenum, give reasonably good localization of pain—in this instance, to the epigastric area. However, diseases of other organs, such as the jejunum and ileum, may produce pain anywhere in the abdomen.
- Radiation of the pain. Certain types of abdominal pain have typical areas of radiation. The pain of

**Table 10.3.—Organs Found in the Abdominal Cavity**

| Right Upper Quadrant | Left Upper Quadrant | Right Lower Quadrant | Left Lower Quadrant |
|---|---|---|---|
| Liver | Spleen | Appendix | Left ovary |
| Gallbladder | Pancreas | Right ovary. | |
| | Part of stomach. | | |
| | Splenic flexure of colon. | | |

pancreatitis, for example, often radiates straight through the back, while that of an inflamed or obstructed gall bladder may radiate around the right side to the angle of the scapula.

- Quality of the pain. Constant abdominal pain is suggestive of inflammatory or destructive involvement of an organ, while cramping, intermittent pain suggests obstruction of a hollow organ (e.g., bowel obstruction, kidney stone).
- Duration of the pain. This information can be used to determine whether the problem is of recent origin or whether it has been present a long time.
- Intensity of the pain.
- Nature of onset. Sudden and abrupt or gradual onset of pain can indicate different injuries.
- Presence of associated vomiting.
- Change in bowel habits.

The age of the patient is also important. Gall bladder problems are unusual before age 20, and bowel obstruction is uncommon in patients under 35. The paramedic will also find it helpful to know what medication, if any, the patient has been taking. A history of antacid ingestion, for example, suggests that the patient may have peptic ulcer disease. The physical examination should be completed as described in Module II.

## Unit 7. Massive Gastrointestinal Bleeding

Massive gastrointestinal (GI) bleeding refers to bleeding that is severe enough to cause hypovolemic shock. Bleeding may occur from any part of the GI tract. Massive bleeding, however, most frequently occurs from the duodenum, stomach, or esophagus.

Massive GI bleeding is most often caused by a duodenal peptic ulcer. Other frequent causes of massive GI bleeding are a gastric peptic ulcer, gastritis, and esophageal varices (enlarged and twisted veins in the esophagus).

In peptic ulcer disease, digestive enzymes and gastric acid destroy a small area of the lining layer of the stomach or esophagus. If the damaged area includes the wall of a vein or artery, there may be massive bleeding.

A duodoenal peptic ulcer causes massive GI bleeding more frequently than does a gastric peptic ulcer. The typical duodenal ulcer patient is a male executive, over 33, who works under emotional and physical stress.

Gastric peptic ulcer is also more frequent in males, but is not related to stress. Gastric ulcers most often occur past the age of 40. They may be benign or may be caused by gastric cancer.

Acute gastritis is an acute inflammation of the superficial layer of the stomach lining. The disorder may be caused by viral or bacterial infection or by ingestion of alcohol or aspirin. Acute gastritis following alcohol or aspirin ingestion can cause massive GI bleeding. Aspirin and alcohol, however, also cause peptic ulcers to bleed, so a history of the ingestion of either drug does not always indicate acute gastritis.

The symptoms of massive GI bleeding include those of hypovolemic shock, as described in Module III. In addition, massive GI bleeding produces hematemesis (vomiting blood) and/or melena (black, tarry stools). Vomited blood may be bright red if it is fresh or may resemble coffee grounds if it has been partly digested.

Other signs and symptoms can indicate the cause of GI bleeding. The ulcer patient may be taking antacids; the acute gastritis patient may have recently ingested aspirin or alcohol. The patient with bleeding esophageal varices usually has symptoms of cirrhosis of the liver. These include liver and spleen enlargement, ascites (fluid in the peritoneal cavity), and dilated abdominal wall veins. To estimate the amount of blood lost in a patient with massive GI bleeding, the EMT–P can use the tilt test described in Chapter 3.

Treatment of massive GI bleeding includes restoring blood volume and maintaining tissue oxygenation. (Treatment for hypovolemic shock is described in more detail in Module III). To accomplish these goals, the paramedic should:

- Administer oxygen.
- Take vital signs.
- Apply and inflate the MAST.
- Start two or more IV's with large-bore (14 to 16 gauge) catheters. Draw blood for typing cross-match, hemoglobin, and hematocrit. Then rapidly infuse normal saline, Ringer's solution, or a plasma derivative.
- If ordered by the physician, insert a nasogastric tube to aspirate blood present in the stomach and begin gastric lavage with ice-cold saline.
- Maintain the patient in the physiologic position, with the feet elevated at a 30° angle.
- Keep the patient warm.
- Monitor the patient's blood pressure, pulse, and state of consciousness.

## Unit 8. Genitourinary Problems

It is rarely useful to distinguish the different possible causes of genitourinary problems in the field. Therefore, this unit will give only a brief overview of the subject.

The genitourinary system includes the kidneys, ureters, bladder, urethra, and the organs of reproduction. All of these organs are subject to trauma or disease.

Nontraumatic emergencies involving these organs include inflammation, infection, and obstruction. One dramatic nontraumatic genitourinary emergency is passage of a renal stone, which causes excruciating flank pain—one of the most severe forms of pain a person can experience. No treatment is feasible in the field, although morphine may be ordered for pain relief if the patient must be transported a long distance.

## Unit 9. Medical Emergencies Involving the Geriatric Patient

With improvements in overall health care, the proportion of elderly patients in the population has risen significantly over the last several years, and will probably continue to rise. For this reason, and also because the elderly are more prone to illness and injury, geriatric patients will make up a significant proportion of the calls received by the Emergency Medical Services team. Therefore, the paramedic must be aware of some of the special problems confronting elderly patients and the health professionals who care for them.

Elderly patients differ from younger patients in several ways, the most important being their altered reactions to illness. These altered reactions include:

- *Depressed pain mechanism.* Pain may be less severe, or the elderly patient may simply discount a certain amount of pain as part of being old. Furthermore, many illnesses that are normally characterized by pain may be entirely painless in the elderly. Myocardial infarction, for example, often has symptoms of confusion or congestive heart failure in the aged patient, and many myocardial infarcts in the elderly occur without any symptoms at all.
- *Depressed temperature-regulating mechanisms.* The elderly patient is less likely to develop fever in response to infection. Furthermore, because of poor temperature control, geriatric patients are more prone to heat exhaustion and accidental hypothermia after relatively moderate exposure to heat.
- *Less reality contact in response to medical illness.* The geriatric patient in congestive heart failure, for example, may show confusion, restlessness, or hallucinations.
- *Increased susceptibility to psychological disorders.* Elderly patients are in general more prone to confusion and depression.
- *Depressed thirst mechanism.* The elderly are more prone to dehydration.
- *Increased susceptibility to generalized deterioration.* A specific illness or injury in an elderly patient is more likely to result in generalized deterioration.

In general, the elderly patient is less likely to present a clearly defined complex of symptoms; more often, the history is vague—a little weakness, a little undefined pain or discomfort, a little fatigue, and so on. The overall handicaps of growing old—failing memory, diminished sight and hearing, arthritis, increased susceptibility to respiratory infection—put the elderly patient at an added disadvantage.

Eliciting a history from an elderly patient often presents a special set of problems. The patient may be confused or unable to remember recent events. Often depression, hopelessness, and hostility make the patient unwilling to cooperate. Furthermore, the expectations of an elderly patient may be very different from those of a younger patient. The elderly patient may neglect to mention significant symptoms, regarding them as "normal for my age." Diminished hearing may also impair the patient's ability to understand and respond to questions. (The paramedic should never assume, however, that simply because a patient is old, he or she is deaf. You will insult many elderly patients through such an assumption.)

Often it will be necessary to verify the history obtained from an elderly patient with a friend or relative. In such cases, this is best done in another room, so that the patient will not be offended by the implication that his or her own account is not reliable. If the patient has a hearing loss, you must speak slowly and clearly, and face the patient so that the patient can see the paramedic's lips.

The physical examination of an elderly patient may also present unique difficulties. Poor cooperation and easy fatigability may require that the manipulations that are necessary for the examination be reduced to a minimum. Often it will be necessary to remove many layers of clothing to examine the patient adequately. The paramedic should resist the tendency, upon viewing the volume of clothing, to skip the examination. The ill or injured geriatric patient deserves as thorough an evaluation as a younger patient.

Physical signs in the aged patient may not have the significance that they have in the young. Inelastic skin may give the impression of dehydration; thus, skin turgor in the elderly is best assessed by examining the lateral cheeks. Similarly, edema in the legs may be caused by inactivity and sitting with the feet hanging down, so this sign cannot always be assumed to be indicative of right heart failure. The elderly also often have crackling rales in the lung bases without having lung disease.

To illustrate some of the above problems, let us discuss two common conditions in the elderly, myocardial infarction and congestive heart failure.

Acute myocardial infarction (AMI) is common in the elderly, and occurs with equal frequency in men and women. Only a small minority of these patients, however, present the classic picture of severe chest pain. Much more frequent is the slow development of dyspnea that indicates left heart failure. Frequently the elderly patient with AMI will also show only extreme weakness, syncope, loss of bowel or bladder control, associated stroke, or confusion. Indeed, as noted above, many elderly patients with AMI experience no symptoms at all, and their infarction is detected only months or years later, by routine electrocardiograms. Therefore, you must be very suspicious of AMI in any elderly patient who has such vague symptoms as weakness, dizziness, or malaise.

Congestive heart failure also afflicts a significant proportion of the elderly population, and again its symptoms may be atypical. Heart failure is particularly likely to show up as mental confusion, and often the paramedic will obtain a history of multiple episodes of nocturnal confusion. Another feature of heart failure in the old that rarely occurs in younger patients is the development of blisters on the legs. These blisters, which are translucent, often multiple, and sometimes quite large, develop when the elderly patient with orthopnea sleeps in his or her chair at night, thereby maintaining the increased hydrostatic pressure in already edematous legs.

In summary, the elderly patient is more prone to illness and injury, but these illnesses are also more difficult to diagnose because of altered responses to illness, vague symptoms, and difficulties encountered in history taking. Confusion is a common sign of serious illness in the elderly patient and should never be dismissed simply as dementia until a careful search is made for underlying disease or injury.

## Unit 10. Techniques of Management

### Nasogastric Tube Insertion

Nasogastric intubation is indicated to decompress a distended stomach or to empty the stomach by lavage. It should be performed only on patients able to protect their airways; that is, on patients who are alert and have an active gag reflex. If nasogastric intubation is indicated in the comatose patient, the paramedic should always first intubate the trachea with a cuffed endotracheal tube to protect the airway.

Nasogastric intubation can be unpleasant for the patient. Paramedics who have learned this skill should practice on one another so that they will appreciate what the patient must go through. The patient will look upon the prospect with foreboding, especially if he or she has been through it before; therefore, you will need to approach the patient confidently and sympathetically, offering assurance that the procedure is necessary. If the patient trusts you, it will be easier to insert the nasogastric tube, since the patient's cooperation is extremely helpful.

An assistant is also helpful. He or she can hold extra equipment, such as a basin of water or emesis basin. In many instances, the assistant can hold the patient (especially if the patient is confused or is a child). To perform nasogastric intubation, the paramedic should:

- Assemble the equipment:
  —Levin tube (No. 18 French for adults and No. 12 French for children).
  —Water-soluble lubricant.
  —Tape of 1-inch width.
  —50 ml syringe.
  —Small clamp.
  —Cup of water with a straw.
  —Emesis basin.
- Explain carefully to the patient exactly what you intend to do and what you expect the patient to do.
- Lubricate the tip and the first few inches of the nasogastric tube generously and place the straw between the patient's lips. Tell the patient not to drink until you give the signal, at which point the patient is to drink as fast as possible without stopping.
- Pass the tube gently along the floor of the nasal passage; hold the tube almost horizontal to the ground to do this. A common mistake is to orient the tip upward, which causes it to become hung up in the turbinates, resulting in pain and bleeding.
- When the tube begins to enter the oropharynx (the paramedic will be able to feel this), tell the patient to drink and keep drinking. Advance the tip into the stomach as the patient swallows. The tube should go about 20 inches down. However, the most reliable indication that the tube has reached the right place is a rapid return of gastric contents when the tube is aspirated with the syringe. Another method to check tube position is to push about 20 ml of air into the tube with a syringe and auscultate over the epigastrium for bubbling sounds.

Possible problems the paramedic may encounter when performing this technique include:

- Accidental passage of the nasogastric tube into the trachea. This should be obvious, because the patient will cough and choke. If in doubt, the paramedic should place the top end of the tube under water; if the other end is in the trachea, there will be a steady bubbling as the patient exhales. If this is the case, withdraw the tube back into the posterior pharynx and advance it again. Having the patient slightly flex the neck sometimes helps avoid this problem.
- Accidental hanging of the tube in the pharynx. A clue that this has occurred is excessive gagging and retching. It is very easy for the paramedic to check this by simply looking in the patient's mouth. If the nasogastric tube is coiled in the patient's throat, the paramedic should pull the

tube back until the tip of the tube is visible in the posterior pharynx and try the procedure again.

## Catheterization of the Urinary Bladder

It is unlikely that the paramedic will need to catheterize a patient's bladder in the field. However, if you are based in an emergency department, you may need to learn this skill. Bladder catheterization is indicated whenever precise measurement of a patient's urinary output is needed and the patient is unable to void voluntarily at appropriate intervals.

Bladder catheterization is also unpleasant for a patient, and again the paramedic's explanations of what will be done and why will be important in establishing the patient's trust. To catheterize a patient's urinary bladder, first assemble the equipment:

- Sterile gloves.
- Sterile cleansing sponges.
- Antiseptic solution (pHisoHex or Zephiran).
- Foley catheter with 5 ml balloon (usually a No. 14 French for women or a No. 16 French for men).
- Sterile towels.
- Syringe with needle, containing 5 ml saline.
- Clamp.
- Water-soluble lubricant.
- Connecting tubing and collecting bag.
- Sterile basin.

Prepackaged catheterization sets are now widely available and quite suitable for use. When such a set is available, the paramedic will not need to assemble the equipment listed above.

To catheterize a male patient, the paramedic should:

- Place a towel beneath the patient's penis.
- Wash the hands and put on sterile gloves; arrange the equipment on a sterile towel where it is handy.
- Retract the patient's foreskin (if present) with the left hand, and hold the penis by the shaft. This hand is no longer sterile.
- Use the clamp to pick up a sterile sponge soaked in antiseptic with right hand. Wash the glans.
- Touch nothing but the catheter with the right hand. Lubricate the urethra by injecting 5 cc of lubricant into the meatus.
- Raise the shaft of the penis straight up with the left hand and rapidly introduce and pass the catheter. Advance it almost to its bifurcation before inflating the balloon.
- Pull back slightly on the catheter so that the balloon will be flush against the prostatic urethra.
- After obtaining a urine specimen, connect the catheter to the drainage system.
- Tape the tubing, not the catheter, to the inner surface of the thigh. Avoid tension on the catheter.
- Never allow the bladder to empty all at once if it is full. Periodically clamp and unclamp the connecting tubing to slow the rate of emptying.

To catheterize a female patient, the paramedic should:

- Place the patient supine, with knees bent and hips canted upward.
- Use the same sterile procedure as listed in catheterization of the male bladder.
- Clean the urethral meatus thoroughly with antiseptic solution.
- Lubricate the catheter tip and advance it into the urethra.
- The subsequent steps are the same as for catheterization of the male bladder.

## Glossary

**addiction:** A marked psychological and physiological dependence on a substance such as alcohol or a drug, which has gone beyond voluntary control.

**anaphylaxis:** An unusual or exaggerated allergic reaction to foreign proteins or other substances.

**aneurysm:** A permanent blood-filled dilation of a blood vessel resulting from disease or injury of the blood vessel wall.

**epigastrium:** The upper and middle regions of the abdomen within the sternal angle.

**ethanol:** Ethyl alcohol; the type of alcohol present in alcoholic beverages.

**geriatric:** A term that refers to the elderly.

**habituation:** A situation in which a patient produces a tolerance to a drug and becomes psychologically dependent on the drug.

**hallucinogen:** An agent or drug that has the capacity to stimulate hallucinations.

**hyperglycemia:** An abnormally increased concentration of sugar in the blood.

**hyperthermia:** An abnormally increased body temperature; hyperpyrexia.

**hypoglycemia:** An abnormally diminished concentration of sugar in the blood.

**hypothermia:** An abnormally reduced body temperature.

**insulin:** A hormone secreted by the islets of Langerhans in the pancreas; essential for proper metabolism of blood sugar and maintenance of proper blood sugar levels.

**intoxication:** A state of being excited or stupefied by alcohol or a narcotic to the point where physical and mental control is markedly diminished.

**ketoacidosis:** A condition arising in diabetics such that the insulin dose is insufficient; blood sugar reaches high levels and fat is metabolized to ketones and acids. Ketoacidosis is characterized by excessive thirst, urination, nausea, vomiting, and sometimes coma.

**lavage:** A washing-out of a hollow organ (such as the stomach).

**methanol:** Methyl alcohol; wood alcohol; poisonous if ingested, causing extreme metabolic acidosis and blindness.

**narcotic:** A drug used to depress the central nervous system, thereby relieving pain and producing sleep.

**peritoneum:** The membrane that lines the abdominal cavity.

**physical dependence:** *See* addiction.

**polydipsia:** A condition of excessive thirst.

**polyphagia:** A condition of excessive hunger.

**polyuria:** A condition of excessive urination.

**psychological dependence:** *See* addiction.

**quadrant:** The term used to designate one of the four quarters of the abdomen.

**retroperitoneum:** The area behind the peritoneum.

**tolerance:** A diminished susceptibility to the effects of a drug or toxic substance acquired after continued ingestion of it.

**urticaria:** Hives.

**vasoconstriction:** The narrowing of the diameter of a blood vessel.

**vasodilatation:** The widening of the diameter of a blood vessel.

**venom:** A poison, usually derived from reptiles or insects.

**withdrawal:** A symptom produced by abstinence from a drug to which one is addicted.

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## Module XI.
# Obstetric and Gynecologic

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## Module XI.

# Obstetric and Gynecologic Emergencies

## Unit 1. Anatomy and Physiology of the Female Reproductive System

In this unit, the basic functions and anatomical structures of the female reproductive system will be summarized, as will the developmental stages of pregnancy and the progression of normal labor and delivery.

### Anatomy

The female reproductive system includes the ovaries, fallopian tubes, uterus, and vagina. The female reproductive organs are located in the pelvic cavity. The uterus is above and behind the bladder. The bladder orifice, the urethra, is in front of the vaginal opening. The rectum and its opening, the anus, are behind the vagina. The vaginal, urethral, and rectal orifices open into the perineum. The perineum is shown in Figure 11.1. Because these pelvic organs are so close to the uterus and vagina, trauma to the reproductive organs can also injure the bladder, urethra, rectum, or anus.

Ovaries—The ovaries, two walnut-shaped organs that produce ova (eggs) are located in the right and left lower quadrants. Progesterone and estrogen, the female sex hormones, also are produced by the ovaries. In the nonpregnant woman, estrogen and progesterone secretions vary cyclically each month. In the pregnant woman, estrogen and progesterone secretions vary according to the stage of pregnancy. Two hormones secreted by the anterior pituitary gland, follicle-stimulating and luetinizing hormone, regulate ovarian hormone secretion.

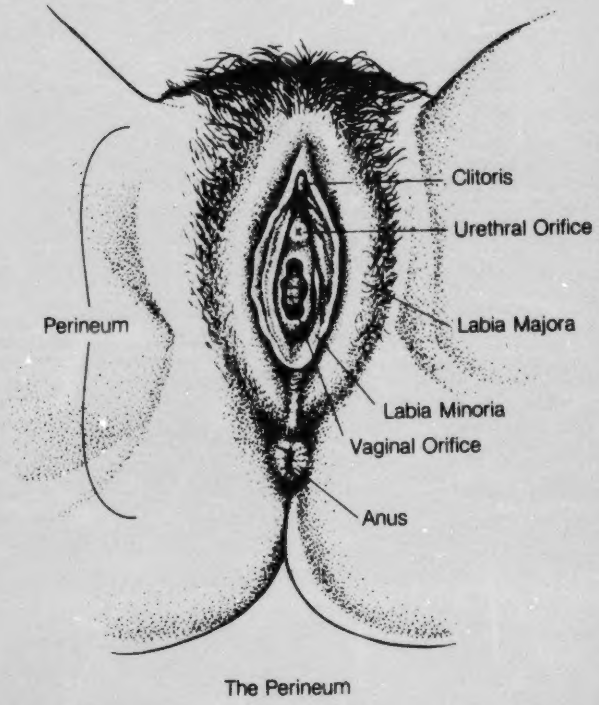


**Figure 1. Perineum**

Estrogen thickens the linings of the uterus (endometrium), fallopian tubes, and vagina. In addition, estrogen produces secondary female sexual characteristics. Estrogen also affects kidney functions. It decreases sodium, chloride, and water excretion, which decreases urine output and increases extracellular fluid volume.

Progesterone can act only on tissues that have been filled by estrogen. Progesterone prepares the reproductive tract for implantation of a fertilized egg. It also prepares the breast for lactation (milk production). Body temperature is slightly increased (0.5° to 1.0° F) by progesterone secretion.

The ovaries release one mature ovum about once a month during the reproductive years. Since the ovaries are not directly connected to the fallopian tubes, the ova enter the peritoneal cavity before being drawn into the fallopian tubes.

Fallopian tubes—The fallopian tubes permit passage of the ova from the ovaries to the uterus. At their ovarian ends, the fallopian tubes are funnel shaped and fringed with small, finger-like structures called fimbria, which insure that the ova reach the fallopian tubes from the ovaries. The fallopian tubes are narrower at their uterine ends.

Uterus, cervix, and vagina—The ovum travels through the fallopian tube into a pear-shaped, muscular organ called the uterus (womb). In the nonpregnant woman, the uterus is about 3 inches high, 2 inches wide, and 1 inch thick. It is located above and behind the bladder. In the pregnant woman, the uterus enlarges and rises upward. By the end of pregnancy, the uterus is 12 inches high, 9 inches wide, and 8 inches thick.

The uterus has three layers: the perimetrium, the myometrium, and the endometrium. The perimetrium is the peritoneal covering of the uterus that separates it from the abdominal cavity. The myometrium, a thick, muscular wall, forms most of the uterus. The thickness of the endometrium, the inner lining of the uterus, varies cyclically each month in nonpregnant women.

During the early part of the menstrual cycle, the endometrium thickens to prepare for ovulation (release of a mature ovum). If the ovum is fertilized by uniting with a sperm cell, it will implant in the endometrium and develop into a fetus. If the ovum is not fertilized, however, the uterus sheds its endometrial lining 14 days after ovulation. A menstrual period, a discharge of a bloody fluid from the uterus, is produced because of shedding of the endometrial lining. Menstrual periods occur about every 28 days and last 3 to 7 days during the woman's reproductive years. Menstrual periods are absent during pregnancy.

During labor and delivery the menstrual flow and the fetus pass through the cervix, a narrow opening at the distal end of the uterus. The cervix connects the uterus to the vagina. The vagina is a muscular tube leading to the external genitalia. The vagina serves also as the birth canal during labor and delivery.

The ovaries, fallopian tubes, uterus, and vagina receive blood from the ovarian, uterine, and vaginal arteries. The ovarian arteries arise from the aorta, just below the origins of the renal arteries. These arteries supply the ovaries, fallopian tubes, and part of the uterus. The uterine arteries mainly supply the uterus. The vaginal arteries mainly supply the vagina. If untreated, the bleeding from these organs may be extensive and fatal, because the blood supply to the internal reproductive organs is complex.

The external female genitalia include the vulval structures which include the labia majora and the labia minora. The labia majora are large, rounded, and lateral skin folds. These enlarge as they pass from the anus and meet at the symphysis pubis. (The symphysis pubis is the anterior joint between the two pubic bones that form part of the pelvic girdle.) The labia minora are smaller skin folds that are between the labia majora and usually are hidden by them.

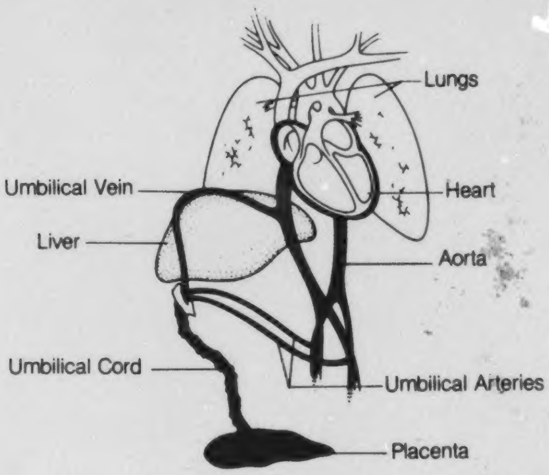
The breasts are secretory glands located on the anterior chest wall. During pregnancy, estrogen and progesterone act on the breasts to prepare them for lactation following delivery. After delivery prolactin and oxytocin, hormones secreted by the pituitary gland, stimulate the breasts to produce milk.

## Pregnancy

Pregnancy begins when an ovum unites with a sperm cell that has been introduced into the female reproductive tract. The union of the ovum and sperm cell is called fertilization, and occurs in the outer third of the fallopian tube. The fertilized ovum passes into the uterus and implants in the endometrium. Implantation usually occurs in the upper part of the uterus.

The fertilized ovum develops into a fetus. The fetus is nourished by the placenta. The placenta, a special disk-shaped organ, develops during pregnancy and attaches to the inner wall of the uterus. The placenta contains both fetal and maternal tissues. Oxygen and nutrients pass from the maternal bloodstream into the fetal bloodstream through the placenta. Carbon dioxide and waste products also pass from the fetal blood vessels into the maternal blood vessels through the placenta. Maternal and fetal blood vessels are in close contact with the placenta, but the two bloodstreams do not mix.

Fetal blood enters and leaves the placenta through blood vessels contained in the umbilical cord, as illustrated in Figure 11.2. These umbilical vessels enter the fetus through the umbilicus, or naval. Two umbilical arteries carry unoxygenated blood from the fetus to the placenta. A single umbilical vein returns oxygenated blood to the fetus.



Fetal Blood Supply

**Figure 2. How Fetal Blood Enters the Placenta**

The combined blood flow into the placenta from the fetal and maternal circulation is large in volume; therefore, any disturbance to the placenta (e.g., separation from the uterine wall or change in position) will cause extensive bleeding and endanger both the fetus and the mother. In addition, blood supply to the entire uterus increases during pregnancy; therefore, uterine injuries also can produce extensive bleeding.

While in the uterus, the fetus is enclosed in the amniotic sac (bag of waters). This sac contains amniotic fluid in which the fetus floats freely. The amniotic fluid helps protect the fetus from mechanical injury. Amniotic fluid is formed from maternal serum and fetal urine; it is reabsorbed into the maternal circulation and also is swallowed by the fetus. At the end of pregnancy, the amniotic sac contains about 1 liter of amniotic fluid. During or before labor, this sac ruptures, and amniotic fluid flows out through the cervix and the vagina.

Physiological changes characteristic of pregnancy are used to determine whether a woman is pregnant and when she will give birth. Pregnancy begins when the ovum is fertilized by a sperm cell, usually about 14 days after the beginning of the last menstrual period. Although it is impossible to determine exactly when fertilization actually occurs, it is easy to determine when the last menstrual period began. Consequently, the duration of pregnancy is usually determined by assuming that pregnancy began on the 1st day of the last menstrual period. Each 4-week period of pregnancy is called a lunar month. There are 10 lunar months in a normal pregnancy. Each 3-month period is called a trimester.

During the first 4 weeks of pregnancy (1st lunar month), the pregnant woman stops menstruating, her breasts enlarge, and she sleeps more than usual. She also urinates more frequently, because the pregnant uterus presses on the bladder.

From the 5th through the 8th week (2d lunar month), she may experience nausea and vomiting in addition to the above symptoms. In the 9th through 12th weeks of pregnancy (3d lunar month), the uterus can be felt above the symphysis pubis, and urinary frequency returns to normal. The pregnant woman begins to feel fetal movement between the 13th and 16th weeks (4th lunar month).

Between the 17th and 20th weeks (5th lunar month), fetal heart sounds can be heard with a stethoscope. By the end of the 24th week (6th lunar month), the examiner can feel fetal movement. Figures 11.3A and 11.3B show the locations of the fundus uteri (top of the uterus) at each month of pregnancy.

During the 37th through the 40th week (10th lunar month), the uterus drops back down as the presenting part descends into the pelvis. The uterus presses on the bladder, and urinary frequency again increases.

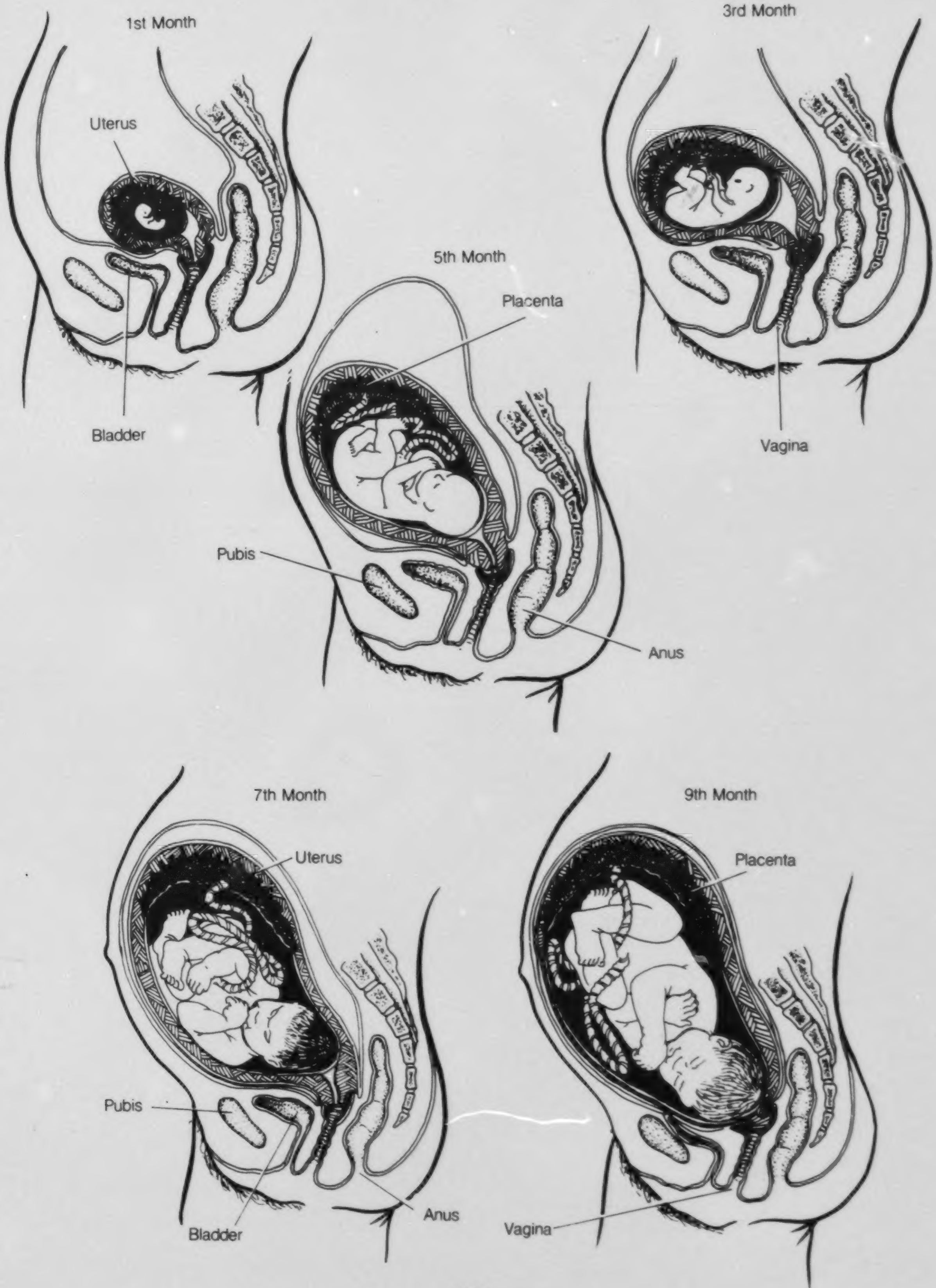
Labor is the process in which the uterus repeatedly contracts to push the fetus and placenta out of the mother's body. Delivery is the actual birth of the baby at the end of the second stage of labor.

Before labor begins, the head of the fetus settles in the pelvis. The cervix then begins to efface, or thin. Effacement may be completed before labor begins or may continue during the first stage of labor.

At the beginning of labor, contractions are far apart. As labor progresses, contractions occur closer together. During the most active stage of labor, contractions occur every 2 to 3 minutes and last 30 to 45 seconds.

There are three stages of labor. The first stage begins with the first uterine contraction and lasts until the cervix is completely effaced and dilated (open). A completely dilated cervix is about 10 centimeters wide. The first stage lasts about 12 hours in a woman who has previously borne a child. The amniotic sac frequently ruptures when the cervix is completely expanded.

The second stage of labor begins when the fetus starts descending into the vagina. Normally, the head descends first; this type of delivery is called cephalic (head). If the buttocks descend first, it is called a breech delivery. During the second stage of labor, the woman will bear down with each contraction. As the presenting part of the fetus presses on the rectum, the woman will feel an urge to defecate. The presenting part will appear and disappear at the vaginal opening between contractions. Eventually, the presenting part will remain visible between contractions. This is called crowning. In a normal delivery, the head will appear first and the shoulders and trunk soon after.


1st Month
Uterus
Bladder
3rd Month
Vagina
5th Month
Placenta
Pubis
Anus
7th Month
Uterus
Pubis
Bladder
Anus
9th Month
Placenta
Vagina

Fetal
Development During Pregnancy

**Figure 3A & 3B Fundus Uteri at each Month of Pregnancy**

The second stage of labor lasts about an hour in a woman having a first baby and from 15 to 20 minutes in a woman who has previously borne a child.

In the third stage of labor, uterine contractions expel the placenta. When the placenta separates from the uterine wall, a small amount of blood gushes out through the vagina. The placenta is then pushed out of the uterus and through the vagina. The third stage of labor usually lasts about 15 minutes.

## Unit 2. Pathophysiology and Management of Gynecologic Emergencies

In general, there is little that paramedics can do to treat gynecologic emergencies in the field. Most common gynecologic emergencies require the attention of a physician or the use of specialized treatment resources not found in the emergency vehicle. However, the paramedic can greatly aid the physician and the hospital staff by obtaining an adequate history from the patient.

### Abdominal Pain

A gynecologic problem, that is, a problem related to the female reproductive organs, should be suspected in any woman who presents with abdominal pain. The following questions should be asked to obtain information necessary for possible treatment.

- When was the patient's last menstrual period? Was it unusual in any way? Has she had any bleeding between menstrual periods or bleeding following menopause?
- Has she missed a menstrual period? Does she use any form of contraception? Could she be pregnant?
- Has she had any vaginal discharge? What color was it? Was it foul smelling?
- Where is the pain exactly? What is it like (sharp, dull, constant, intermittent)? What makes it better? What makes it worse? Is it made worse by sexual intercourse? How long has it been between the onset of the pain and the last menstrual period?

Pelvic inflammatory disease (PID)—Often resulting from gonorrhea, PID is one of the most common sources of abdominal pain in women. The pain, sometimes diffuse, is localized to one of the lower quadrants. It may spread to the right shoulder and is often quite severe. In many cases, the pain begins at about the time of the menstrual period. It may be accompanied by fever and vomiting. The pain frequently is worsened by sexual intercourse. The patient usually complains of moderate to heavy vaginal discharge. The patient's recent menstrual history often is characterized by missed periods and by bleeding between periods.

Physical examination often reveals a very ill-appearing patient. In general, blood pressure is normal, and pulse is elevated. Fever may be present. Palpating the abdomen causes moderate to extreme pain and should be done very gently. No treatment in the field is necessary for patients with PID. Such patients should be made comfortable in whatever position they prefer and transported gently to the hospital.

Other sources of abdominal pain—Other possible sources of abdominal pain in women include ectopic pregnancy (i.e., the fetus growing in a location outside of the uterus, e.g., in the fallopian tube), ruptured ovarian cyst, and nongynecologic causes such as appendicitis and cystitis (bladder inflammation). Differentiating these conditions in the field is not vitally important, because management for most consists of support and transport of the patient. Ectopic pregnancies, however, must be distinguished from other causes of abdominal pain as they can lead to hypovolemic shock. Recognition and treatment of ruptured ectopic pregnancies will be discussed in Unit 3 of this Module.

### Vaginal Bleeding

Vaginal bleeding may follow trauma or may occur in its absence. General management of abnormal vaginal bleeding will be discussed in the following section.

#### VAGINAL BLEEDING WITH NO HISTORY OF TRAUMA

In questioning a patient who complains of vaginal bleeding, it is important for the paramedic to try to estimate the amount of blood lost. What may seem like an alarming amount to the patient may be clinically insignificant. The patient should be asked how long she has been bleeding and how many sanitary napkins she has used. The paramedic should determine whether the bleeding has been heavier or lighter than during a normal menstrual period, as well as what the patient has used to absorb the blood (towels generally soak up less blood than a sanitary napkin.) Blood loss can be assessed further in the physical exam by checking for variations in pulse rate because of change in posture. An increase in pulse rate of more than 20 beats per minute when the patient goes from a supine to a sitting position suggests blood loss greater than one unit. If this finding is positive, the paramedic should treat the patient like any other patient in impending shock by:

- Administering oxygen.
- Placing the patient supine with the legs slightly elevated.
- Starting an intravenous (IV) line with normal saline or Ringer's solution and infusing it rapidly.

- Following vital signs closely en route to the hospital.

Vaginal bleeding accompanied by genital trauma—Rape or other trauma may result in lacerations of the external female genitalia. Lacerations may be accompanied by heavy bleeding. Usually this bleeding can be controlled simply by applying external pressure over the laceration. Bleeding from the internal genitalia can be massive. It is both useless and dangerous to introduce packs blindly into the vagina in an attempt to control bleeding. A pack should be used only if bleeding is life threatening, in which case a sterile towel or sterile 2-inch gauze tape should be tightly packed into the vagina. The Military Anti-Shock Trousers (MAST) apparatus will probably not help control bleeding from the internal genitalia but will provide an autotransfusion effect of approximately two units and should, therefore, be applied. In a case of massive hemorrhage, the patient with severe vaginal bleeding needs at least one and preferably two or three IV lines for rapid infusion of normal saline, Ringer's solution, or a plasma derivative. Other standard measures for shock also apply. Vital signs must be monitored minute by minute, and transport to the hospital should be rapid.

## Caring for the Rape Victim

Rape presents a difficult and complex problem, involving physical and emotional trauma as well as possible legal ramifications. It is essential that a good history be obtained from the rape victim. In questioning the patient, the paramedic must use tact and sensitivity. The patient may find it extremely difficult to discuss what has happened and may fear or feel hostile toward a male paramedic. Every effort should be made to understand the patient's feelings and to respond with kindness and reassurance. The emotional trauma of rape is usually more prolonged and severe than the physical trauma. The attitude shown toward the patient during her care can have a serious influence, for good or ill, on her future psychological and physical recovery.

A primary assessment should be conducted for the rape victim. The paramedic should observe whether the patient's clothes are torn or in disarray. The paramedic also should check for trauma elsewhere on the patient's body, especially around the thighs, lower abdomen, and buttocks. If vaginal bleeding is significant, it should be treated as outlined earlier.

The report submitted by the paramedic to the emergency department should state only what the patient said not what the paramedic observed. The paramedic's opinion as to whether the patient was raped should not be included in the report. Every rape is a potential court case, and the report is a legal document. Therefore the paramedic should be thorough and accurate.

# Unit 3. Pathophysiology and Management of Obstetric Emergencies

Emergency obstetrics situations in which the paramedic will be likely to become involved include normal labor and delivery, complications of labor and delivery, and conditions that can be life threatening to the pregnant woman or to the fetus before labor.

Serious medical problems that the pregnant woman may encounter before labor are termed ante partum complications. In this unit, several types of ante partum complications will be discussed: five conditions involving hemorrhage and several other conditions involving supine hypotensive syndrome and toxemia.

## Ante Partum Hemorrhage Complications

Hemorrhage complications occurring before delivery are classified as ante partum complications. Five ante partum hemorrhage conditions will be discussed in this section: abortion, ectopic pregnancy, abruptio placentae, placenta previa, and uterine rupture.

### ABORTION

Abortion is defined as loss of pregnancy before the 20th week of gestation (the 20th week of fetal growth). It often is referred to by laypeople as a "miscarriage." Abortions can occur spontaneously or can be induced. Induced abortions performed under sterile conditions in authorized medical settings are termed therapeutic abortions. Abortions that occur naturally fall into one of the four categories discussed below.

### THREATENED ABORTION

Signs and symptoms of threatened abortion include vaginal bleeding, pain resembling menstrual cramps, and, occasionally, dilation of the cervix. This condition can progress to complete abortion or may subside, and the pregnancy may go to term. A woman with a threatened abortion should be evaluated at the hospital. The treatment is bedrest.

### INEVITABLE ABORTION

An abortion that cannot be prevented is termed an inevitable abortion. Signs of an impending abortion include vaginal bleeding, which can be very heavy, uterine contractions, and cervical dilation. For a patient with such symptoms, the paramedic should start a IV line with normal saline or Ringer's solution. She should be transported to the hospital as quickly as possible. Fluids should be given as rapidly as possible to maintain blood pressure during transport.

### INCOMPLETE ABORTION

An incomplete abortion occurs when part of the fetus is expelled and part of the products of conception remain within the uterus. This situation causes hemorrhage and continued cervical dilation. The patient should be treated for shock if it is present. Products of conception protruding from the cervix should be gently removed to prevent sepsis. Paramedics should consult a physician for instruction in treating a patient with an incomplete abortion.

### MISSED ABORTION

In a missed abortion, the fetus dies before 20 weeks gestation but is retained in the uterus for at least 2 months after death. When the uterus hardens, fetal heart sounds are no longer present. The patient with a missed abortion should be taken to the hospital for further treatment.

### ECTOPIC PREGNANCY

The fertilized ovum may implant abnormally in the fallopian tube, ovary, or abdomen, rather than in the uterus. Implantation in the fallopian tube (tubal pregnancy) is far more common than implantation in either the ovary or the abdomen; such a condition is very rare. Ectopic pregnancy is also 10 times more frequent in women who become pregnant with an IUD in place.

Fertilization normally occurs in the fallopian tubes. In a tubal pregnancy, the fertilized ovum fails to travel into the uterus and is implanted in the fallopian tube as shown in Figure 11.4. Abnormalities of either the ovum or the fallopian tubes can prevent the ovum from reaching the uterus. Tubal abnormalities can result from developmental defects, previous infection and scarring, as in pelvic inflammatory disease, or cancer involving the tube.

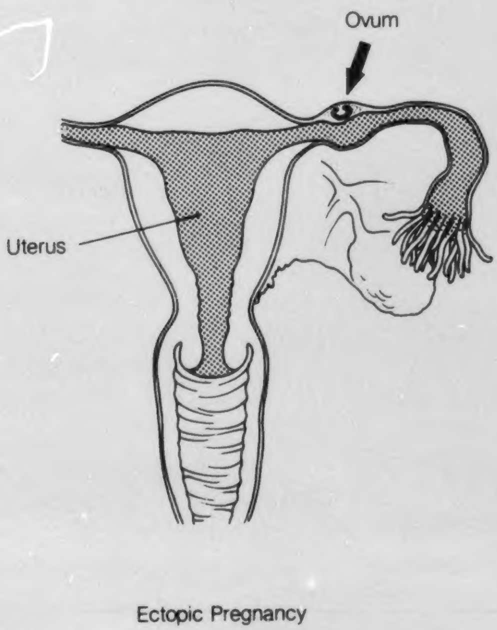


**Figure 4. Tubal Pregnancy**

When the fertilized ovum implants in the muscular layer of the fallopian tube, it invades maternal blood vessels. The fallopian tube does not enlarge as the fetus grows, and the tube eventually ruptures. This rupture may be either internal in the tube lumen or external in the abdominal cavity, and the resulting blood loss may be entirely hidden.

The patient with a ruptured tubal pregnancy may complain of severe pain localized to one lower quadrant. She may have vaginal bleeding. If blood enters the abdominal cavity, it will irritate the peritoneum and cause fever. The accumulated blood produces a mass that is tender to palpation.

As blood loss continues, hypovolemic shock develops. The pulse becomes rapid; and the skin becomes pale, cold, and moist. When the body can no longer compensate for the decreased blood volume, the blood pressure falls.

Hypovolemic shock due to ruptured ectopic pregnancy should be treated in the same way as hypovolemic shock because of other causes. (Treatment for hypovolemic shock is described in detail in Module III.) To treat hypovolemic shock, the paramedic should:

- Administer oxygen.
- Support ventilation, if necessary.
- Take vital signs.
- Apply and inflate the MAST.
- Start two or more large-bore (14- to 16-gauge) IV lines, and then rapidly infuse normal saline, Ringer's solution, or a plasma derivative.
- Place the patient in supine position with feet elevated 30°.
- Keep patient warm.
- Monitor state of consciousness, pulse, and blood pressure during transport.

### ABRUPTIO PLACENTAE

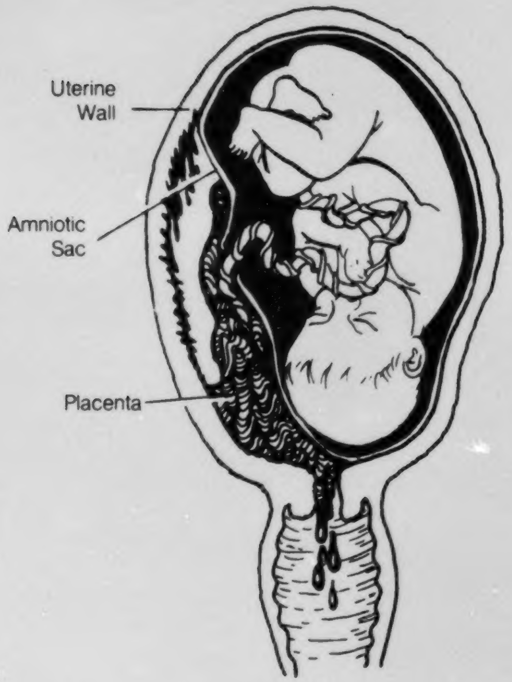
Abruptio placentae occurs when a normally implanted placenta separates prematurely from the uterine wall during the last trimester of pregnancy, as illustrated in Figure 11.5. The patient experiences severe lower abdominal pain, and the uterus becomes rigid. Shock may be more severe than the apparent blood loss would seem to indicate.

### PLACENTA PREVIA

Placenta previa is a condition in which the placenta, rather than the baby, is the presenting part. This condition occurs in the third trimester. Again, hemorrhage may be severe from the highly vascular placental tissue. An example of placenta previa is shown in Figure 11.6. Pain is frequently absent in this disorder.

### UTERINE RUPTURE

Uterine rupture is manifested by sudden, severe abdominal pain. Bleeding may not be apparent external-



Abruptio Placentae

**Figure 5. Abruptio Plancentae**

ly, but profound shock can occur from internal hemorrhage.

To treat the patient for shock, the paramedic should:

- Place the patient horizontally on a stretcher, preferably on her side.
- Administer oxygen.
- Apply the MAST to produce autotransfusion.
- Start at least two large-bore IV lines, and administer 50-percent dextrose in normal saline (D5NS), D5W dextrose in Ringer's solution, or a plasma derivative as rapidly as needed to maintain blood pressure.
- Transport the patient to the hospital.

## Other Ante Partum Conditions

The paramedic may also encounter other serious ante partum conditions such as supine hypotensive syndrome and toxemia.

Supine hypotensive syndrome—The pregnant woman near term has a large, heavy mass in her abdomen. When she is supine, this mass, which includes the weight of the uterus, fetus, and placenta, tends to compress the inferior vena cava. Venous return to the heart is thereby reduced, and, as a result, cardiac output falls. These changes are especially pronounced when the mother's vascular volume is low to begin with, such as in ante partum hemorrhage. When a pregnant patient near term who is hypotensive or complains of dizziness is encountered, she should be placed on her side. Severe hypotension indicates a possibility of significant internal hemorrhage. Severe hypotension should be treated like hypovolemic shock as discussed above.

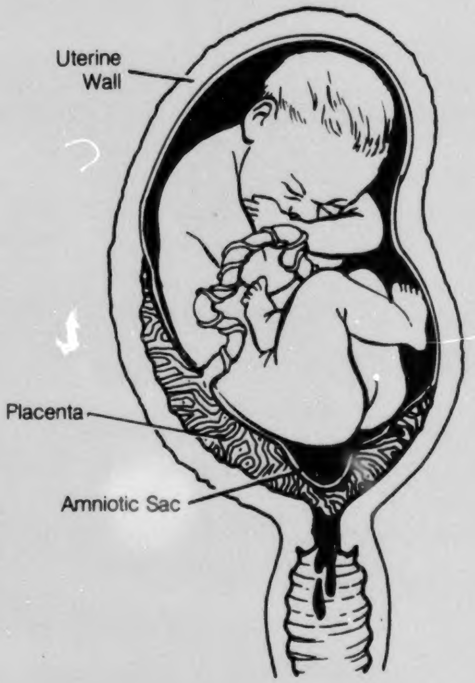
### TOXEMIA OF PREGNANCY

Toxemia of pregnancy has two stages, preeclampsia and eclampsia. Preeclampsia is characterized by hypertension (blood pressure greater than 140/90), proteinuria (protein in the urine), and edema during the last 3 months of pregnancy. Eclampsia follows preeclampsia and includes convulsions and coma in addition to the signs of preeclampsia.

In preeclampsia, renal blood flow and glomerular filtration are below the normal level for pregnant women. Thus, urine output and sodium excretion decrease. This condition increases extracellular fluid volume and produces edema in the ankles, fingers, and face.

Other symptoms of preeclampsia are headache, mid-upper abdominal pain, and blurred vision. Elevated blood pressure and edema, however, are necessary for a diagnosis of preeclampsia. The paramedic, therefore, should report the blood pressure and the presence or absence of edema in every pregnant woman examined for any complaint.

The patient with preeclampsia should be evaluated by a physician in the emergency department for possible hospitalization. When transporting the patient, the



Placenta Previa

**Figure 6. Placenta Previa**

paramedic should remember to be prepared to treat preeclampsia, because it can progress to eclampsia with convulsions and coma.

Eclampsia can occur before, during, or after labor. It begins with convulsions that are usually followed by coma. The eclamptic patient, like the preeclamptic patient, has pronounced hypertension and edema. Her urine will be scant and bloody. She also may show signs and symptoms of pulmonary edema.

Although the physician should be contacted for specific directions in treating eclampsia, the paramedic can do the following:

- Establish and maintain an airway; administer oxygen.
- Start a IV line with D5W to keep open. Do not use normal saline or Ringer's solution as they will increase the fluid overload.
- If convulsions occur and the physician orders diazepam (Valium), administer 5–10 milligrams (mg) slowly IV line; if 10-percent magnesium sulfate is ordered, administer 2–4 mg slowly IV line.
- Administer furosemide (Lasix) to reduce extracellular fluid volume, if ordered by the physician.
- Transport the patient gently to the hospital without flashing red lights or sirens, because they can cause convulsions.

In ante partum hemorrhage of any kind, the paramedic should not attempt to examine the patient internally.

## Normal Delivery

Assisting in the birth of a baby is one of the few situations in which the paramedic will have the opportunity to participate in a happy event, rather than an unpleasant one. The situation is also unique because the paramedic is dealing with two patients, the mother and the baby, both of whom require skilled attention.

When paramedics arrive at the scene of a woman in labor, they first will need to determine whether there is time to transport the patient to the hospital. To make this decision, the paramedic should answer the following questions:

- Has the mother had a baby before? Labor during a first pregnancy is usually slower than in subsequent pregnancies; therefore, there may be more time for transport during a first labor.
- How frequent are the contractions? Contractions more than 5 minutes apart are a good indication that there will be enough time to get the patient to a nearby hospital. Contractions less than 2 minutes apart, especially in a multiparous woman (a woman who has had more than one pregnan-

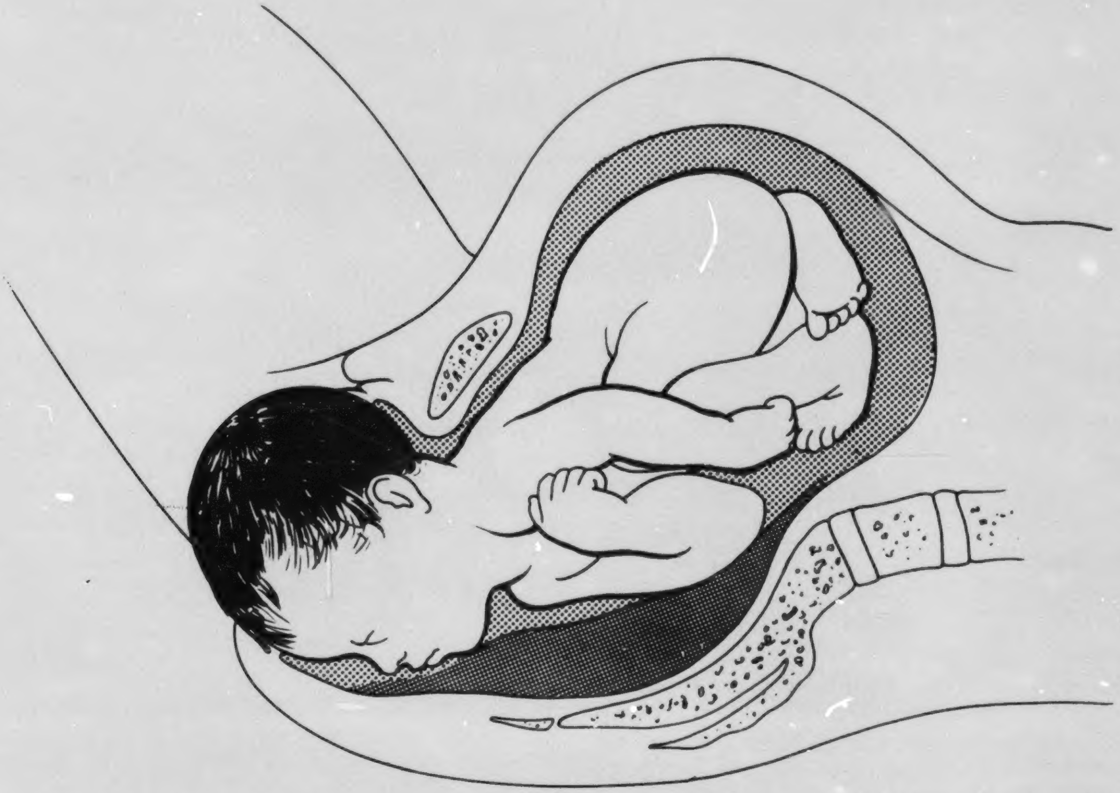
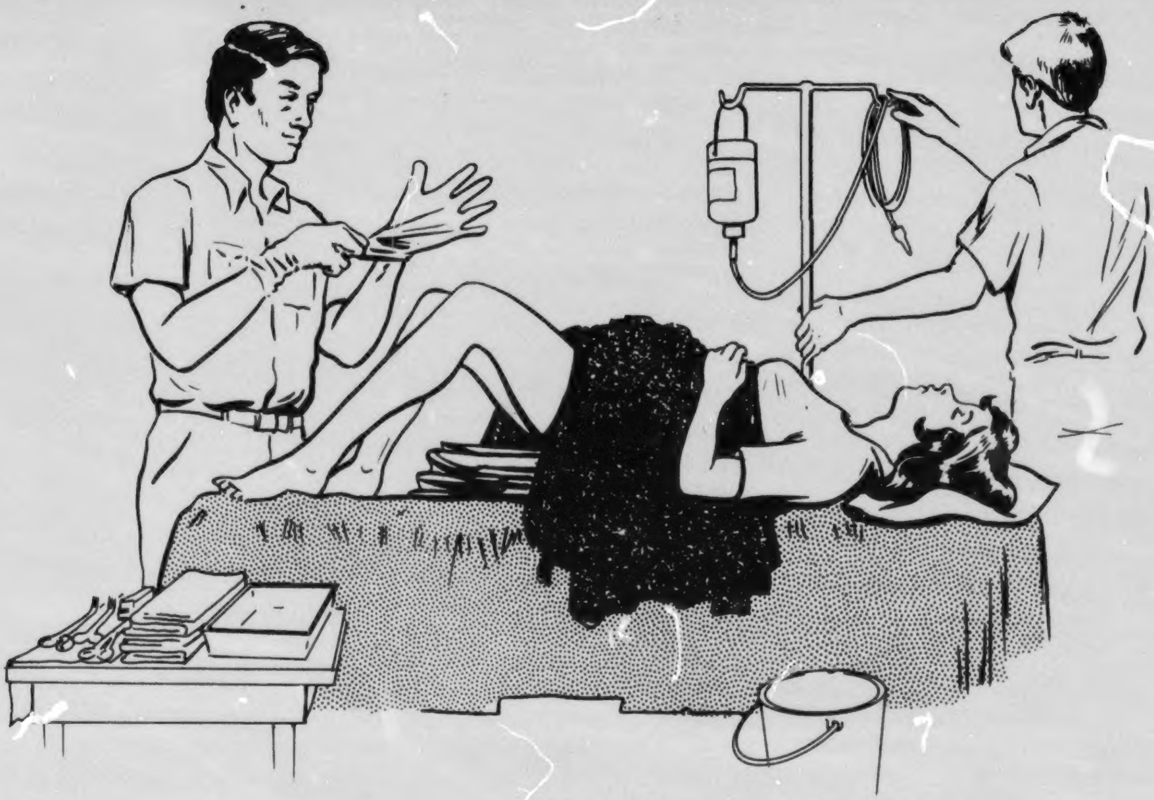


**Figure 7. Crowning**



Prepare for Delivery

**Figure 8. Mother in Birth Position**

cy, sometimes called a "multip" for short), signal impending delivery.

- Has the amniotic sac ruptured and, if so, when? If the sac ruptures more than 18 hours before birth occurs, the likelihood of fetal infection is increased, and the hospital staff should be alerted. Furthermore, delivery may be more difficult when the amniotic sac has ruptured prematurely, because amniotic fluid serves as a lubricant.
- Does the mother feel as though she has to move her bowels? This sensation is caused by the fetal head in the vagina pressing against the rectum and indicates that delivery is imminent.

The mother also should be examined to see whether the fetus is crowning. When crowning occurs, the vaginal opening will bulge outward and the presenting part of the fetus will be visible at the opening (see Fig. 11.7). Crowning indicates that the fetus is about to be born, and that there will not be time to go to the hospital before delivery.

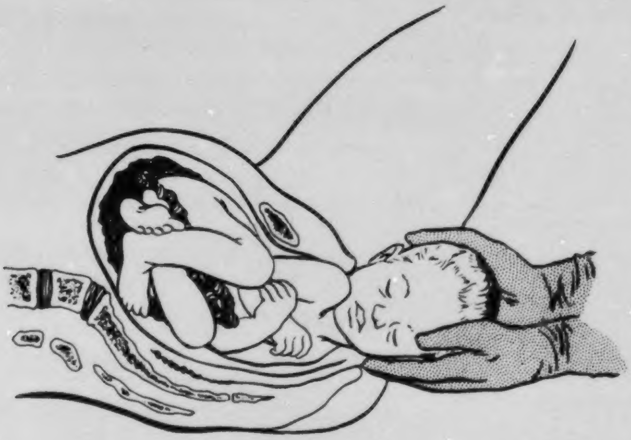
If there is enough time to transport the patient to the hospital, she should be placed in a reclining position. Any underclothing that may obstruct delivery should be removed. The paramedic should:

- Never allow the mother to go to the toilet.
- Never attempt to delay or restrain delivery in any way.

If there is not enough time to get to the hospital, the paramedic must prepare to assist in the delivery. If the mother is in a crowded or public place, the paramedic should try to find a private, clean area to work. The patient may find it reassuring to have her husband or a friend present. Paramedics should remain calm, because this will exert a calming influence on the patient and any others present.

The patient should be positioned on her back, on the stretcher or in bed, and a folded sheet or drape should be placed under her buttocks. She then should bend her knees and spread her thighs apart, as shown in Figure 11.8. As soon as the paramedic and the assistant finish positioning the mother, the assistant should start an IV line with one l. of D5W to keep open rate. The paramedic should go then to the mother's head and be prepared to turn her head to the side if she vomits. An oxygen tank and suction apparatus should be made readily available.

Hands should be washed thoroughly before the obstetrical (OB) kit is opened. *Betadine scrub* solution should be kept with the kit for this purpose. The OB kit should be opened, and the paramedic should put on sterile gloves. The mother should be draped with four towels so that everything except the vaginal

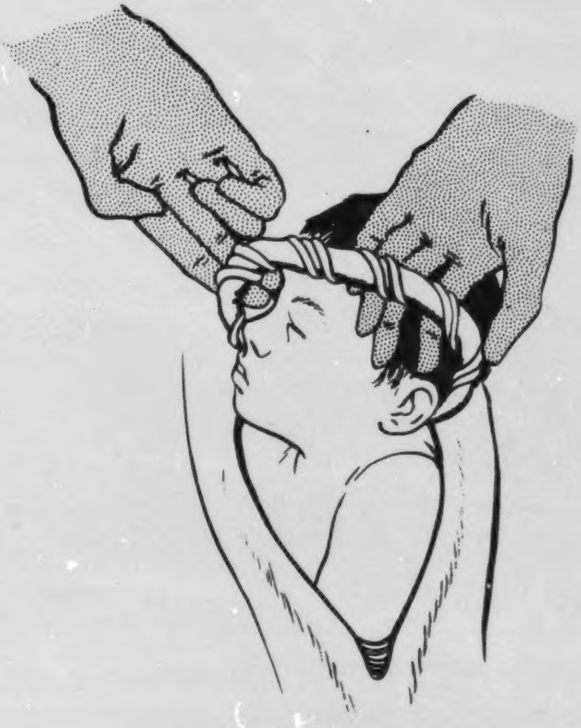


Support Baby's Head

**Figure 9. Paramedic Supporting Baby's Head at Birth**

opening is thoroughly covered. If the baby is coming fast, it is more important for the paramedic to assist in the delivery than to put on drapes or gloves. The paramedic should encourage the mother to relax and to take slow, deep breaths through her mouth and should continue to reassure her and explain everything that is being done.

When the baby's head begins to emerge from the vagina, it should be supported gently to prevent explosive delivery. This procedure is illustrated in Figure 11.9. The paramedic should not attempt to pull the baby from the vagina. If the membranes cover the head after it emerges, the sac should be torn with fingers or forceps and removed from the infant's face to permit the amniotic fluid to escape to enable the infant to breathe. The paramedic must be sure the umbilical cord is not wrapped around the infant's neck; if so it should be slipped gently over the shoulder or head, as illustrated in Figure 11.10. If this maneuver fails and the cord is tight around the baby's neck, umbilical clamps should be placed rapidly on the cord 2 inches apart and the cord should be cut between the clamps to release pressure from the infant's neck (see Fig. 11.11). The shoulder and body should be delivered as shown in Figure 11.12 with the head supported at all times. The paramedic should avoid touching the mother's anus during delivery. The time of birth should be recorded.



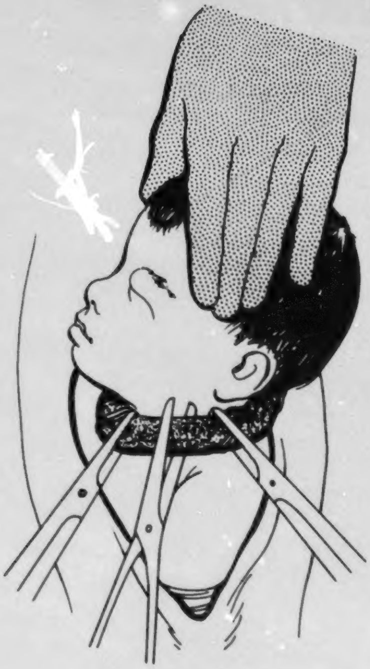
Slip Cord Over Baby's Head

**Figure 10. Paramedic Slipping Cord Over Baby's Head**

After the baby is fully delivered, he or she should be supported along the length of the paramedic's arm, with one arm and shoulder supported by the paramedic's cupped fingers. The infant's head should be held downward to aid drainage, as in Figure 11.13. Because they are slippery, babies must be held carefully. Blood and mucus from the nose and mouth should be wiped away with a piece of sterile gauze. The mouth and both nostrils should be suctioned with a bulb aspirator. The paramedic should squeeze the bulb before inserting the tip of the aspirator and then place the tip in the mouth or nostrils and release the bulb slowly. This procedure is illustrated in Figure 11.14. The contents of the bulb can be expelled into a waste container, and suctioning can be repeated as often as needed.

If the baby does not breathe spontaneously, the paramedic should stimulate the infant by rubbing the back gently or slapping the soles of the feet. If there is still no response, the paramedic should start mouth-to-mouth or mouth-to-nose resuscitation, remembering that newborn infants are very little and, thus, require very small puffs of air. Mechanical resuscitation devices should never be used on a newborn infant. If spontaneous breathing begins, oxygen should be administered by mask for a few minutes until the baby's color is pink. If breathing is still absent, however, and no precordial pulse can be determined with the stethoscope, cardiac compression should be started and cardiopulmonary resuscitation should be continued en route to the hospital. The baby should be kept wrapped in a blanket as much as possible.

If, however, the infant has been delivered normally and is breathing well, the cord should be clamped about 6 inches from the infant's navel with two clamps set 3 inches apart, as shown in Figure 11.15. If clamps are unavailable, two umbilical ties can be substituted. The cord should be cut between the two ties and handled gently, because it will tear easily. The end of the cord that is attached to the infant must be



Clamp and Cut Immediately

**Figure 11. Paramedic Cutting Cord**

examined to be certain there is no bleeding. If there is bleeding from the cut end, the cord nearest the clamp should be tied and reexamined. The baby should then be wrapped in a sterile blanket to maintain body temperature.

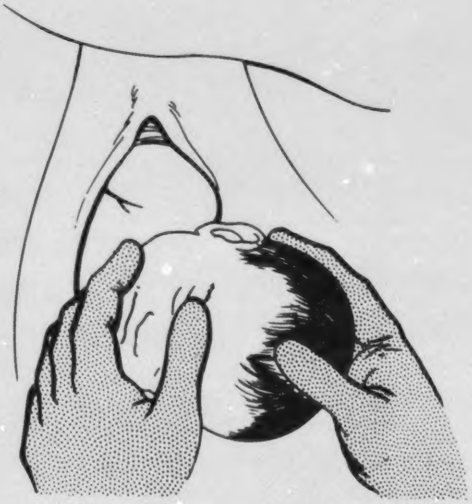
During the next stage of delivery, one paramedic should stand at the mother's head and keep an eye on the infant, while the other paramedic tends to the delivery of the placenta. The placenta usually is delivered spontaneously within 15 to 20 minutes after the infant's birth. Bleeding can be expected as the placenta separates from the uterine wall. When bleeding occurs, the uterus should be gently massaged as shown in Figure 11.16. The uterine massage will stimulate the uterus to contract, thus constricting blood vessels within its walls and decreasing bleeding. Allowing the infant to nurse following the delivery of the placenta will control bleeding, because nursing stimulates the release of oxytocin. Oxytocin, in addition to causing milk ejection, stimulates uterine contraction, which constricts uterine blood vessels.

The paramedic should never pull on the umbilical cord to deliver the placenta. Pulling can invert the uterus (cause it to turn inside out). When the placenta is delivered, it should be placed in a basin or plastic bag and taken to the hospital where it will be examined for completeness. This procedure is necessary, because pieces of placenta retained in the uterus cause persistent bleeding. The perineum, the skin between the anus and the vagina, should be examined for lacerations, and pressure applied to any bleeding tears with a sanitary napkin. A sanitary napkin should be placed over the vagina, the mother's legs can be lowered, and she can be prepared for transport to the hospital. If the physician orders it, the mother can be given 10 units of oxytocin (Pitocin) slowly IV line.

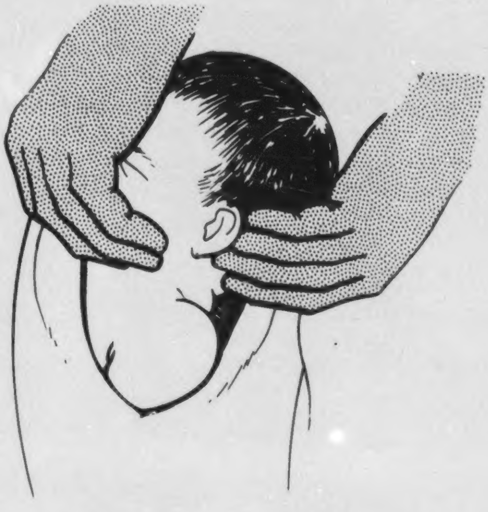
If the placenta is not delivered within about 15 to 20 minutes after the baby's delivery, the mother and baby should be transported to the hospital without delay.

## Complications of Delivery

Three types of problems that can accompany delivery will be discussed in this section: post partum hemorrhage, uterine inversion, and pulmonary embolism. The paramedic should be prepared to treat each of these situations as it occurs.

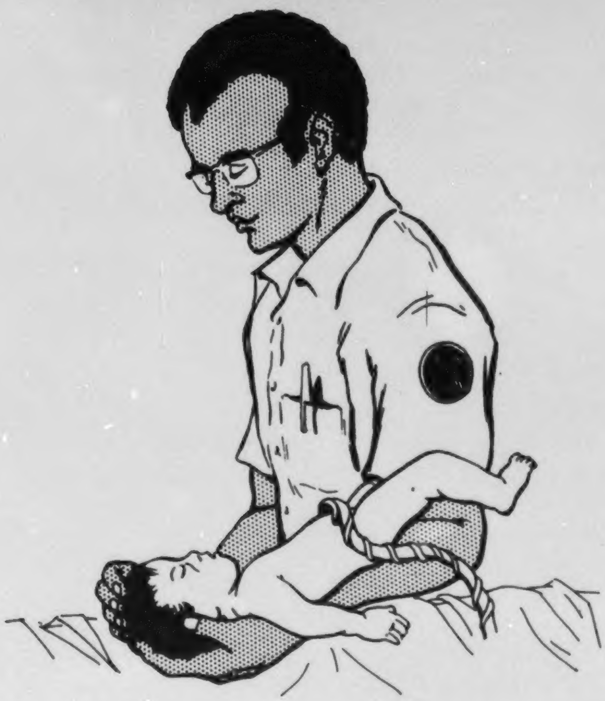


Delivery of Right Shoulder



Delivery of Left Shoulder

**Figure 12. Paramedic Delivering Baby's Body**



Drainage Position

**Figure 13. Paramedic Aiding Drainage of Mucous**

Post partum hemorrhage—Post partum hemorrhage occurs after delivery and is characterized by internal or external bleeding.

Internal bleeding—Internal bleeding may be caused by retained placental tissue, inadequate uterine contractions, or clotting disorders. If bleeding is severe, uterine massage should be continued, and the baby should be allowed to suckle the mother's breast. The paramedic can add 10 units of oxytocin to the IV line bottle following delivery of the placenta. If bleeding persists, the circulation can be supported with a IV line of normal saline, Ringer's solution or plasma derivative. The patient should be transported rapidly to the hospital, and the usual measures for shock should be applied. Vaginal examination or blind packing of the vagina should be avoided. Gentle uterine massage should be continued en route to the hospital.

External bleeding—External bleeding from perineal tears can be managed with firm pressure. It may be necessary to open the labia to apply packs to the bleeding site.

### UTERINE INVERSION

Inversion, or turning inside out, of the uterus can occur as a result of excessive pressure on the uterus or from pulling on the umbilical cord in efforts to deliver the placenta. Shock commonly accompanies uterine inversion. Should this condition occur in the field, the paramedic should take the following steps:

- Keep patient flat.
- Administer oxygen.
- Start two IV lines with Ringer's solution or colloid, running them as fast as necessary to maintain blood pressure.
- Never try to remove the placenta if it is still attached.
- Try once to replace the uterus manually by exerting pressure first on the area closest to the cervix. If the uterus cannot be replaced easily, pack all protruding tissues lightly with moist, sterile towels, and move the patient rapidly to the hospital.

### PULMONARY EMBOLISM

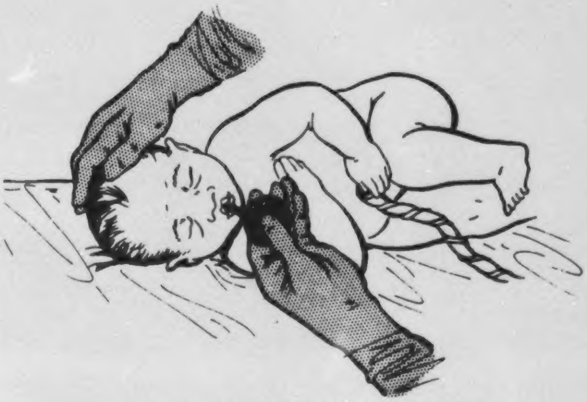
Sudden dyspnea, tachypnea, tachycardia, and/or hypotension in the mother post partum can signal pulmonary embolism, either from a blood clot or from amniotic fluid. Field treatment is the same as for any patient with pulmonary embolism and includes administration of oxygen, electrocardiogram monitoring, and rapid transport to the hospital.

## Abnormal Deliveries

Deliveries in which the fetal head does not present first are classified as abnormal deliveries. Three abnormal presentations will be discussed in this section: breech presentation, prolapsed umbilical cord, and limb presentation. These three situations can be potentially life threatening to the infant, and thus the paramedic should become familiar with the special problem of each situation.

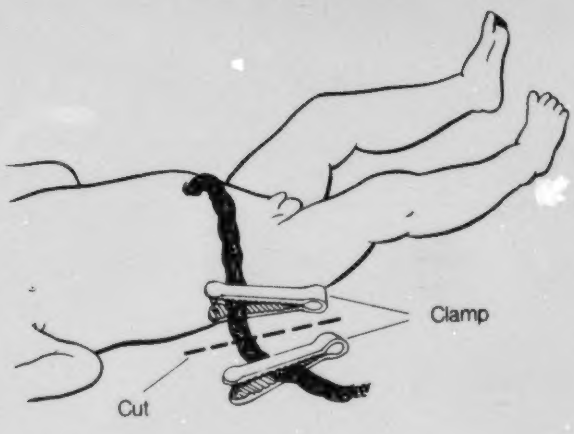
### BREECH PRESENTATION

Breech presentation occurs when the buttocks rather than the head present first. Breech delivery is not simple. If delivery is imminent, the mother should be prepared as discussed earlier, and the buttocks and trunk of the baby should be allowed to deliver spontaneously. Once the legs are clear, the baby's body should be supported on the palm of the paramedic's



Suctioning of Newborn's Airway

**Figure 14. Paramedic Aspirating Baby's Nose and Mouth**



Cutting Infant's Cord

**Figure 15. Where to Clamp Cord for Cutting**

hand and the anterior surface of the paramedic's arm, thus allowing the head to deliver, as shown in Figure 11.17. If the head is not delivered within 3 minutes, action must be taken to prevent suffocation of the infant. Suffocation can occur when the baby's face is pressed against the vaginal wall or when the umbilical cord is compressed by the baby's head in the vagina. To establish an airway in the first instance, the paramedic should:

- Place a gloved hand in the vagina, positioning the palm toward the baby's face.
- Form a "V" with the fingers on either side of the baby's nose.
- Push the vaginal wall away from the baby's face until the head is delivered.

To relieve pressure on the umbilical cord, the paramedic can use one of the following techniques:

- Place the patient in a supine (Trendelenburg) position, apply gentle pressure to the buttocks, and force the baby back into the uterus and out of the vagina.
- Place a gloved hand inside the vagina with fingers separated, allow the cord to pass through the opening created by the fingers between the cervical side wall and the baby's head.

The paramedic should neither try to pull the baby out of the vagina nor allow explosive delivery. If the head does not deliver within 3 minutes after an airway has been established, the mother should be placed in the Trendelenburg position and be transported rapidly to the hospital. The baby's airway should be maintained throughout transport.

## PROLAPSED UMBILICAL CORD

Prolapsed umbilical cord occurs when the cord comes out of the vagina before the baby, as shown in Figure 11.18. The baby is, therefore, in danger of suffocation, the paramedic should:

- Place the mother supine or on her side (in the Trendelenburg position) with her hips elevated on a pillow, and make sure she is kept warm.
- Administer oxygen to the mother.

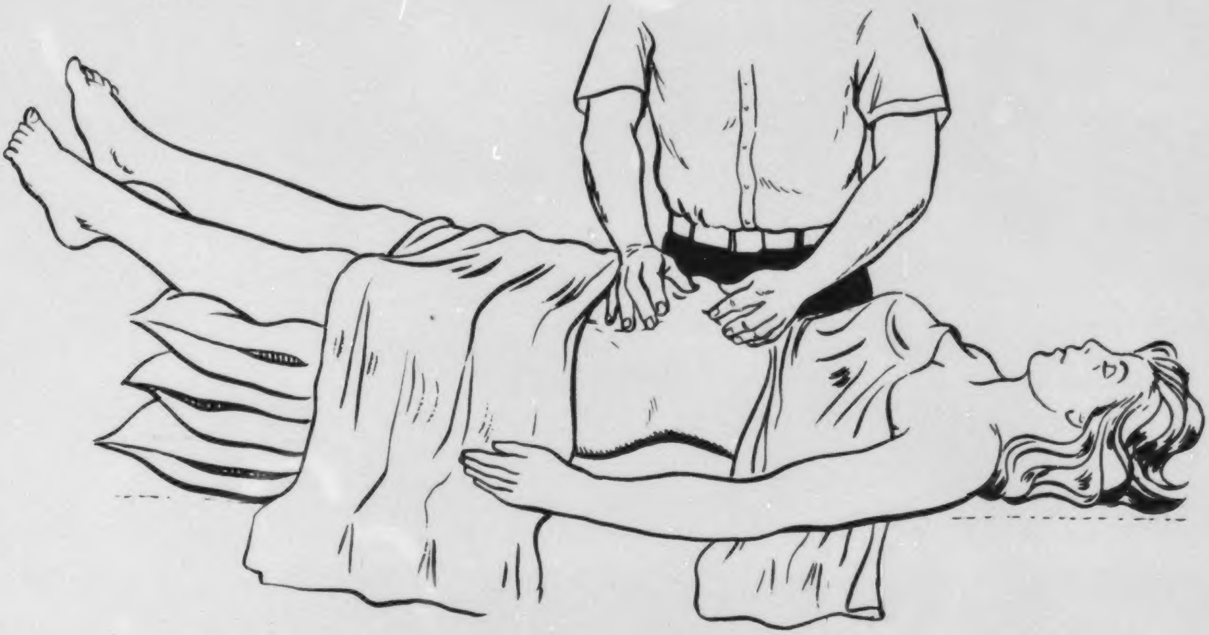


**Figure 16. Paramedic Massaging Uterus**

- With a gloved hand, gently push the baby back up into the vagina several inches, as shown in Figure 11.19.
- Never attempt to push the cord back.
- Transport the mother and the baby to the hospital at once, while maintaining pressure on the baby's head (pressure should be evenly distributed to avoid injury to the baby's soft skull.)

(Breech presentation and prolapsed umbilical cord are the only two cases in which the paramedic should place his or her hand in the mother's vagina.)

### LIMB PRESENTATION

The presentation of an arm or leg through the vagina is an indication for immediate transport to the hospital, the only place where such a delivery should be attempted.

## Other Childbirth Situations

Other unusual childbirth situations that the paramedic may encounter include multiple and premature births. These are of primary concern, because premature infants, and occasionally multiple-birth infants, require special care because of their small size.

### MULTIPLE BIRTHS

Multiple births usually do not present any unique problems. Twins are delivered in the same manner as single babies. Twins should be anticipated if the mother's abdomen appears unusually large, or if it remains large after the first baby is delivered. If twins are expected, the mother should be transported to the hospital as quickly as possible. After the first baby is born, the cord should be tied to prevent hemorrhage from the twin. If the second baby is not delivered within 10 minutes of the first, the mother should be transported to the hospital for delivery of the second twin. Twins tend to be small, like premature infants, need special protection against a fall in body temperature. It is essential that the twins be kept warm during transport.

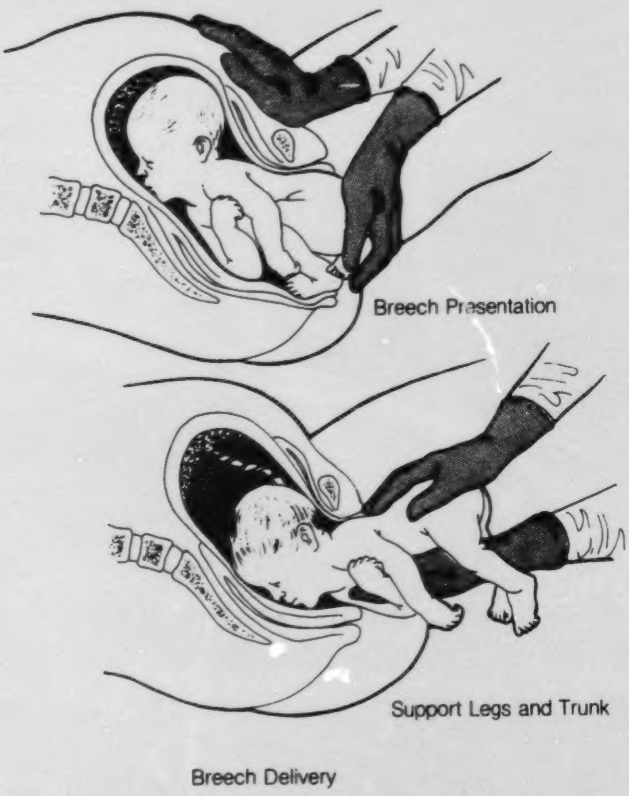


Figure 17. Paramedic Handling a Breech Position

### PREMATURE BIRTHS

Any baby born before 7 months of pregnancy or weighing less than 2,500 grams (g) (5.5 pounds) is defined as premature and needs special care. Birth weight alone is not an adequate definition for prematurity, because low-birth-weight infants may be fully mature. Conversely, premature infants may be over 2,500 g if they are edematous, or if their mothers are diabetic. To distinguish premature from mature infants, the paramedic should observe the creases on the soles of their feet, breast size, type of scalp hair, and presence or absence of cartilage in their outer ears. Infants of less than 36-weeks (8-months) gestation have a single anterior sole crease; breast nodules that are 2 millimeters (mm) or less in diameter; fine, fuzzy scalp hair; and absent external ear cartilage. The heads of premature infants are also larger in proportion to their bodies than those of full-term infants. Infants of at least 39-weeks gestation have creases covering the soles of their feet, breast nodules 7 mm or more in diameter; coarse, silky scalp hair; and cartilaginous outer ears.

Premature infants develop problems, because they are so small and their organs are immature. Premature infants have trouble maintaining a normal body temperature, because they have more surface area relative to their size than older people and, therefore, lose heat more rapidly in a cool environment. In addition, premature babies have less subcutaneous fat to insulate them against heat loss.

Small blood losses are also more serious in premature infants because of their small size. The 2,500-g infant has a total blood volume of about 275 milliliters (ml). Therefore, 30-ml blood loss represents 10 percent of the infant's total blood volume.

Premature infants often develop respiratory problems, because their lungs are immature. Alveoli and alveolar capillaries begin developing at 28-weeks gestation. Surfactant, which lowers alveolar surface tension and allows even expansion of the alveoli, develops at about 28-weeks gestation

Hypoxemia due to respiratory problems leads to cardiovascular problems in the premature infant. Before birth, blood is shunted past the lungs and oxygenated in the placenta. After birth, special mechanisms change the blood flow pattern, so that blood is oxygenated in the lungs. These special mechanisms, how-

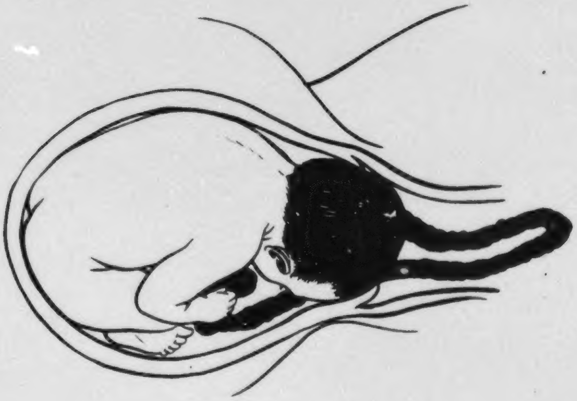


**Figure 18. Prolapsed Cord**

ever, depend on adequate oxygenation of the blood by the lungs. When oxygenation is inadequate because of lung immaturity, blood continues to be shunted past the lungs. This worsens the hypoxemia. Hypoxemia because of respiratory and cardiovascular problems produces cyanosis and leads to bradycardia (in the newborn infant, bradycardia is a heart rate less than 100) and hypotension.

The premature infant also tolerates asphyxia normally occurring during labor and delivery less well than the full-term infant. The mature infant survives some asphyxia during labor and delivery by metabolizing liver and heart glycogen stores. The premature infant, however, has less stored glycogen and, therefore, is less able to tolerate asphyxia.

To manage the premature infant the paramedic should:

- Keep the baby warm. Wrap the baby in aluminum foil and blankets to reduce heat loss.
- Keep the baby's nose and mouth clear of fluid with a bulb syringe.
- Prevent bleeding from the umbilical cord, because these infants cannot tolerate the loss of even small amounts of blood.
- Give oxygen into a tent constructed from aluminum foil above the infant's head. Do not blast it directly into the infant's face.
- Prevent contamination because premature infants are highly susceptible to infection.

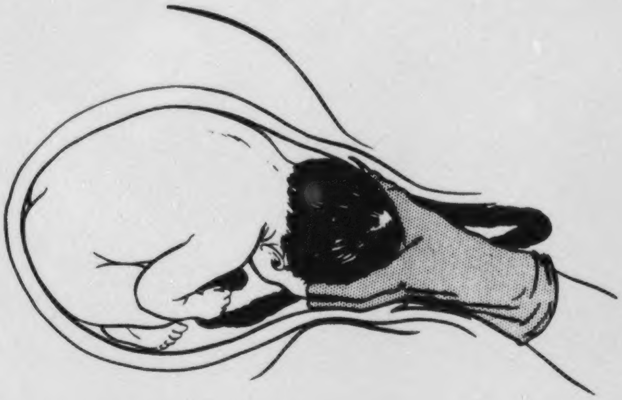
## Apgar Scoring

It is important for the newborn to be evaluated immediately after birth to determine adequacy of vital functions. The scoring system, devised by Virginia Apgar, is helpful in this evaluation. It is based on heart rate, respiratory effort, muscle tone, reflex irritability, and color. Sixty seconds after the birth of the infant, these five signs are evaluated and each given a score of 0, 1, or 2. When added together, numerical ratings yielding a total score of 10 indicate that the infant is in excellent condition. The majority of infants are vigorous and have a total score of 7 to 10; they cough or cry within seconds of delivery and require no further resuscitation. Infants with a score in the 4 to 6 range are moderately depressed. They may be pale or blue 1 minute after delivery with poorly sustained respiration and flaccid muscle tone. Such infants will require some form of resuscitation.

The five signs to be evaluated in Apgar scoring are most easily remembered by using the mnemonic APGAR, as shown in Table 11.1.

**Table 11.1.—Apgar Score**

| Sign | Score | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| A—Appearance (color). | Blue, pale.... | Body pink, extremities blue. | Completely pink. |
| P—Pulse (heart rate). | Absent......... | Slow or less than 100. | Greater than 100. |
| G—Grimace (reflex irritability). | No response. | Grimace.......... | Cough or sneeze. |
| A—Activity (muscle tone). | Limp............ | Some flexion of extremities. | Active motion. |
| R—Respiration (respiratory effort). | Absent......... | Slow, irregular. | Good, crying. |



Gently Push Baby Back

**Figure 19. Paramedic Pushing Baby Back Into Vagina**

## Glossary

**abortion:** Premature expulsion of the products of conception from the uterus; abortion can occur naturally or can be artificially induced.

**incomplete abortion:** When part of the fetus or parts of the products of conception are expelled; when parts of the products of conception are expelled from the uterus and parts remain inside.

**inevitable abortion:** An abortion that cannot be halted; characterized by vaginal bleeding, uterine contractions and cervical dilation before term.

**missed abortion:** An abortion when the fetus dies before 20 weeks gestation but is retained in the uterus for 2 months following death.

**spontaneous abortion:** An abortion occurring naturally.

**therapeutic abortion:** A legal, induced abortion performed under sterile conditions in an authorized medical setting.

**threatened abortion:** The appearance of signs and symptoms of possible loss of the fetus, characterized by bleeding and cramps.

**abruptio placentae:** A premature separation of a normally implanted placenta from the uterine wall, usually occurring during the third trimester of pregnancy and accompanied by pain and hemorrhage.

**amniotic fluid:** The fluid that surrounds the fetus in the uterus, contained in the amniotic sac.

**amniotic sac:** A thin, transparent sac that holds the fetus suspended in amniotic fluid.

**Apgar score:** A method, developed by Virginia Apgar, for assessing the newborn by designation of a score between 0 and 2 for the infant's *a*ppearance (color), *p*ulse (heart rate), *g*rimace (reflex irritability), *a*ctivity (muscle tone), and *r*espiration (respiratory effort) at 1 minute after birth.

**breech delivery:** A delivery in which the presenting part of the fetus is the buttocks or foot instead of the head.

**cephalic delivery:** A delivery in which the fetus emerges head first; generally considered the normal mode of delivery.

**cervix:** The lower portion or neck of the uterus.

**crowning:** The stage of birth when the presenting part of the fetus is visible at the vaginal orifice.

**eclampsia:** A toxic condition that can occur during pregnancy; characterized by hypertension, edema, proteinuria, and seizures.

**fallopian tube:** The tube extending from an ovary to the uterus.

**fetus:** An unborn child after the 2d month of pregnancy.

**labor:** The muscular contractions of the uterus designed to expell the fetus from the mother.

**limb presentation:** A delivery in which the presenting part of a fetus is an arm or a leg.

**menstrual period:** The time period of the menstrual flow, usually from 3 to 7 days.

**ovary:** The female sex organ in which eggs and female hormones are produced.

**ovum:** An egg, plural form is ova.

**perineum:** The region of the body in which the urethral, vaginal, and rectal orifices open.

**placenta:** A vascular organ attached to the uterine wall that supplies oxygen and nutrients to the fetus, also called the afterbirth.

**placenta previa:** A delivery in which the placenta is the presenting part, may result in exsanguinating hemorrhage.

**preeclampsia:** The condition that precedes eclampsia or toxemia of pregnancy, characterized by hypertension and edema.

**presenting part:** The part of the fetus that emerges first during delivery.

**prolapsed cord:** A delivery in which the umbilical cord is the presenting part; fetal suffocation is a danger in this delivery.

**toxemia:** A condition sometimes occurring during the second half of pregnancy, manifested by symptoms of eclampsia.

**vagina:** The genital canal in the female extending from the uterus to the vulva, the birth canal.

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## Module XII.
# Pediatrics

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## Module XII.

# Pediatrics

## Unit 1. Approach to the Pediatric Patient

The sick or injured child presents unique challenges because the child's perceptions of medical problems and of the Emergency Medical Technician-Paramedic (EMT-P) may be radically different from an adult's. Fear or pain may turn the child into a howling banshee whose behavior can (understandably) cause anxiety and confusion among all concerned. With patience and compassion, however, many problems can be overcome.

### Patient Assessment

Often, a child's mother or father must provide most of the necessary patient information. This may be colored by the parents' desire to present themselves as "good parents." Generally, you should be supportive of this tendency; parents often feel guilty when their child is ill or injured. Do not be accusatory—for example, do not ask, "Why did you wait so long to call?" Instead, encourage parents to talk about their guilt and reassure them that it is common for parents to feel that way.

However, in taking the history, don't forget the child. Even the youngest child can sometimes provide valuable information, particularly if you encourage the child to project the answers onto a neutral object ("Where does your dolly hurt?"). As children grow older, they become quite accurate in reporting their discomfort. Certainly once children reach school age, they should play an important part in the history-taking, and their comments should be treated respectfully. Many pediatricians listen to the child's story first ("First I'd like to talk with Johnny, and then we'll see what mother has to say"). This gives the child the floor and indicates that her or his opinions are considered important.

In dealing with adolescents, you must respect their developing feelings of independence. Adolescents need to feel that they are being treated like adults and that the confidentiality of their remarks will be kept. Discuss first with adolescent patients what they plan to tell their parents.

For the physical examination, the techniques will vary according to the child's age. In a life-threatening situation, however, you cannot take too much time for preliminaries and must manage conditions as if the patient were an adult. When there is enough time for assessment, however, certain techniques can be helpful.

Infants between 6 and 12 months will probably not object to being put on a bed and undressed, as long as there are distractions, such as cooing or other pleasant noises. For children up to school age, it is preferable to conduct the secondary survey in toe-to-head order, since small children as a rule do not like having their faces touched by strangers.

Babies (6 to 12 months) do not like being taken away from their mothers. Therefore, it is better to examine them while they are sitting on their mothers' laps. If the situation is not urgent, it is worth taking the time for a little play to let them get acquainted with you. Again, the secondary survey is conducted from toe to head.

Two- to three-year-olds are usually difficult, no matter how charming the examiner tries to be. They do not want to be touched or to play with you. They are usually frightened, and there is nothing anyone can do to convince them of your good intentions. With these children, you should decide which parts of the physical exam are essential and get through them as quickly as possible. It is helpful to establish ground rules for the child's behavior (e.g., crying is allowed; kicking and biting are not).

Four- to five-year-olds, by comparison, are usually cooperative, except when very frightened, and often can be examined sitting alone on a chair or bed. These children enjoy "helping out"—for example, listening to their own hearts with a stethoscope.

School-age children are also likely to be cooperative. They appreciate being treated with respect and like to have an explanation of what is being done. ("This is called a stethoscope, and it helps me listen to the sounds your heart makes.")

Adolescents are apt to be concerned about their bodily functions and appearance. When your results are positive, you might reassure the teenager as you go along. For example, after listening to the chest, you might say, "Your lungs are certainly in good shape." This will relieve anxiety.

Guidelines for the normal vital signs of different age groups can be found in Table 12.1.

## Special Considerations

In general, ill or injured children are frightened by their condition. These children are also frightened by strangers and think the strangers might harm them. More, they don't want to be separated from their parents. After accidents, injured children may also be frightened by injuries to other family members and by the noise and confusion or an atmosphere of panic or distress.

**Table 12.1.—Normal Vital Signs at Different Ages**

| Age | Respiratory rate | Blood pressure | Pulse |
|---|---|---|---|
| Newborn | 50 | 70–75 systolic | 120 |
| 12 weeks | 60 | 85 systolic | 120 |
| 6 months | 35 | 90/60 | 110 |
| 1 year | 30 | 95/65 | 110 |
| 2 to 4 years | 24 | 100/65 | 100 |
| 5 to 7 years | 21 | 95/65 | 100 |
| 8 to 10 years | 20 | 95/65 | 90 |
| 12 years | 16 | 105/70 | 85 |
| 14 years | 16 | 110/75 | 80 |
| 16 years | 16 | 120/70 | 75 |

It is important to be aware of these fears. In dealing with children of any age:

- Be calm, patient, and gentle.
- Be honest. Children should not be told that something will not hurt if it will.
- Try not to separate children from their parents, even if they are injured as well. Under such circumstances, children's normal separation anxiety will only be heightened by worries that something terrible has happened to their parents.

The specific manner in which to approach sick or injured children depends on their age. Since infants cannot communicate and are distressed by separation, mothers should be allowed maximum contact with their child at the scene and in transit.

One- to three-year-olds are similarly very dependent on their mothers and should not be separated from them. Medical procedures should be explained to these children in language they can understand. But children of this age have a limited sense of time, so there is no need to discuss what might happen in the emergency room; doing so will only create anxiety.

Three- to five-year-olds live in a world of fears—monsters, aggression, punishment, death. This is the age when fear of mutilation is at its worst. Even a minor cut sends these children shrieking to their parents, and the sight of blood can cause panic. By this age, many children associate medical people with a variety of unpleasant experiences, such as getting shots—so they may not greet your arrival with much enthusiasm.

Furthermore, children of this age tend to view an illness or injury as a punishment for their aggressive feelings, or they interpret such procedures as starting an intravenous (IV) line as hostile acts. You must be extremely patient. After an accident, you can cover the bleeding areas while assuring the child that no limbs or other vital parts have been lost or left at the scene. (You may think this is obvious—but it's not; to the 3-year-old, it's vitally important.)

Explain each procedure to children, and reassure them that everything will be all right. If the child has a cherished belonging like a blanket or teddy bear around, you might suggest that it be brought along. Children of this age may be told what to expect at the hospital, depending on what worries they express ("Will I get a shot?"). Preschoolers also need to be reassured that it is all right to cry or complain.

School-age children are not immune to the anxieties that preoccupy younger children. However, they can communicate better, which helps in dealing with such feelings. Their natural curiosity can also be used to help them cope with illness or injury. School-age children like to be treated with respect, and rank honesty high on their list of adult virtues. You should try to make them partners in what you are doing and explain each procedure in detail. Some may be interested in learning about the equipment in the ambulance. For school-age children, information is reassuring, so they should be prepared for what will happen when they reach the emergency room. Again, how you proceed should depend on what questions the child asks.

Adolescents may worry about how their condition will affect them: Will a facial laceration leave a disfiguring scar? Will a fracture prevent them from competing in sports forever?

Adolescents need the kind of support given all sick children, but at the same time, they want to be treated with the respect given adults. Therefore, you must offer support and reassurance—but also be factual and answer questions as you would for adults.

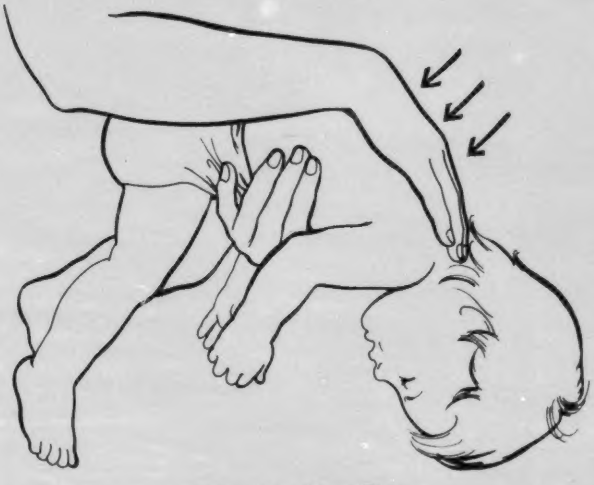
## Unit 2. Pathophysiology and Management

Most emergencies involving infants and children are discussed in other modules. However, some pediatric emergencies are either unique to children or are handled differently. This section deals with those emergencies.

### Respiratory Emergencies

Module V discussed the problem of the obstructed airway. However, certain principles deserve repeating:

- If the child is not breathing, try to open the airway manually, using a backward tilt of the head or triple airway maneuver.
- If unable to ventilate the child, clear the airway of any easily accessible materials. Observe the cords and remove obstructing matter with a forceps, suction, or fingers.
- If unsuccessful, try delivering a sharp blow to the back. Both infants and small children can be held upside down and slapped between the shoulder blades (Figure 12.1). They should not be slapped too hard, however, as excessive force may injure the child. Older children can be rolled on their sides or leaned forward over the back of a chair to deliver a few sharp blows between their shoulder blades. Then quickly clear the airway of anything that has been dislodged and attempt once again to ventilate the child.



Delivering a Sharp Blow

**Figure 1. Dislodging Obstruction in Infant**

**Asthma** is a common problem in children and often is associated with allergies. About 50 percent of asthmatic children "outgrow" their asthma; the rest continue to have asthmatic attacks into adulthood. *Every asthmatic attack should be regarded as a serious medical emergency.*

The acute asthmatic attack is marked by spasm and constriction of the bronchi (bronchoconstriction). Edema (excessive fluid retention) and congestion of the bronchial membranes result. Secretions of thick mucus block the airways. Expiration is impaired so that air becomes trapped in the lungs at the end of each exhalation. As a result, the chest becomes hyperinflated and hyperresonant to percussion, and ventilation becomes more impaired. At the same time, the patient develops increasing hypoxemia, hypercarbia, respiratory acidosis (a retention of carbon dioxide), and dehydration. As the acidosis worsens, bronchoconstriction worsens and dehydration makes the mucous plugs thicker and stickier. Thus, a vicious cycle is started. Procedures to use include: bronchodilators to counteract bronchoconstriction, fluids to treat dehydration and loosen up mucus, oxygen to treat hypoxemia, mechanical methods for increasing ventilation, sodium bicarbonate to reduce respiratory acidosis, and possibly steroids to reduce edema and congestion of the bronchial membranes.

A very severe asthmatic attack that cannot be broken with epinephrine, a drug commonly used for treatment, is called status asthmaticus.

In an evaluation of the acute asthmatic attack, you should establish:

- How long has the patient been wheezing?
- How much has the patient had to drink during this time?
- Has the patient had a recent infection, particularly one involving the respiratory tract?
- What, if any, medications has the patient taken for this attack? When were they taken, and how much? It is especially important to ask about inhalant medications.

- Does the patient have any known allergies (to drugs, foods, inhalants)?
- Has the patient ever been hospitalized for an acute asthmatic attack? How recently? How often?

During the examination, pay particular attention to:

- **General appearance.** Note the patient's position. Is he or she in much distress? Patients with mild asthmatic attacks usually prefer to sit, but will lie down; these patients may be somewhat excited. Patients with severe attacks will appear exhausted and may be unable to move. These patients usually are leaning forward and bracing their elbows.
- **State of consciousness.** Sleepiness, stupor, and coma are signs that usually indicate severe degrees of hypercarbia, hypoxemia, and acidosis.
- **Vital signs.** As the attack worsens, note that the pulse grows faster and weaker and that the blood pressure may fall.
- **Skin and mucous membranes.** Test for dehydration by pinching the skin. Dehydrated skin remains pinched (tented). Check lips and nail beds for evidence of cyanosis (bluish discoloration).
- **Respiratory movement.** Look at the chest to assess respiratory movement, which will be increased in the mild asthmatic attack but may be entirely absent in the severe attack. Listen to the chest for rales and wheezes. In the mild-to-moderate attack, breath sounds become less and less audible. In the very severe attack, breath sounds are entirely absent. Listen to the entire chest. Localized wheezes suggest obstruction by a foreign body. In contrast, asthma wheezing is generalized.

The features of asthmatic attacks are summarized in Table 12.2. Remember that infants may not show the fear or positional preferences of older children. Severely asthmatic infants may lie on their backs in apparent comfort; sometimes, even if cyanotic, they may smile and can be easily distracted by toys and

**Table 12.2.—Severity of Asthma**

| Criteria | Mild | Moderate | Severe | Extreme |
|---|---|---|---|---|
| Duration of wheezing. | Less than 12 hours | More than 12 but less than 24 hours. | Usually more than 24 hours. | Unknown; may be unlimited. |
| General appearance | Normal or excited; seldom true anxiety. | Normal or moderate anxiety; mild fatigue. | Frightened; deep anxiety; very fatigued. | Drowsy, comatose, or unconscious. |
| Cough | Deep; produces some clear mucus. | Repetitive shallow cough; produces little sputum. | Unable to cough | Unable to cough. |
| Posture | Prefers to sit but can lie down. | Semireclining posture possible. | Cannot move from preferred position; i.e., sitting, thorax angled upward. | Lies in any position; usually is placed semireclining. |
| Respiration chest excursion. | Normal or increased | Normal or moderately decreased. | Fixed in inspiration; no visible movement. | No chest movement; shallow abdominal movements; at times paradoxical. |
| Color | Normal or somewhat red (hyperventilation). | Normal or subcyanotic. | Ashen gray or deeply cyanotic. | Deep cyanosis. |
| Pulse rate | Normal or moderate tachycardia (100–120). | Moderate tachycardia, 120–140. | Marked tachycardia, greater than 140 entirely at times. | Rapid, thready pulse that may disappear. |
| Breath sounds | Normal or increased | Normal or moderately decreased. | Barely audible to absent. | Usually absent. |
| Rales | Numerous | May or may not be present. | Occasional very high-pitched. | Usually none. |
| Wheezes | Present | Marked | High-pitched or absent. | Absent. |

cooing. Infants may also show extreme tachypnea (respiratory rates of 60–80 per minute), marked by quick, shallow breathing.

Treat the acute asthmatic attack as follows:

- Administer humidified oxygen, if possible, by an intermittent positive pressure breathing (IPPB) apparatus; otherwise by mask.
- If at all possible, start an IV line with dextrose in water (D5W) or dextrose in one-fourth normal saline (D5 ¼NS). Use a winged infusion needle in the hand veins of small children. Secure this well. Run the IV at the rate specified by the doctor. (This rate is usually in the range of 5–15 milliliters per kilogram per hour (ml/kg/hour), depending on how dehydrated the child is.)
- Give epinephrine 1:1000 by subcutaneous injection in a dose of 0.01 milligram per kilogram (mg/kg). Average subcutaneous doses are:

| | |
|---|---|
| 4½ months to 1 year | 0.1 mg. |
| 1 to 2 years | 0.15 mg. |
| 2 to 3 years | 0.2 mg. |
| 3 years and over | 0.3 mg. |

The physician may instruct you to repeat this dose. If the patient fails to respond to epinephrine—this is known, again, as status asthmaticus—other treatment may be required. (Caution: Using epinephrine may be hazardous to a patient who has already taken a high dose of bronchodilator medications by inhalation. It is important to find out what the patient has taken and report this to the physician before any epinephrine is given.)

- If a mechanical ventilator or an appropriate attachment for a bag-valve mask is available, add 0.5 ml of racemic epinephrine or isoetharine to 2.5 ml of saline in the nebulizer, and administer IPPB for 5 to 10 minutes. Monitor heart rate, and discontinue IPPB immediately if the heart rate exceeds 160 per minute or if arrhythmias develop. Encourage the child to cough up any secretions. Isoproterenol should not be given by any route to the child who has been given epinephrine.

If patients have available in their homes other means for delivering nebulized bronchodilators, like handbulb or gas-propelled nebulizers, it is likely that they have already tried these methods. This is important to ascertain, as occasionally it may be necessary to give patients a dose of bronchodilator from their own supply. You should:

- Treat status asthmaticus through the use of such drugs as:
  - —Sodium bicarbonate, to treat the acidosis: 1 milliequivalent (mEq)(1 ml)/kg, to be given IV over 5 minutes.
  - —Aminophylline, as a bronchodilator: 2-4 mg/kg diluted in at least 10 ml of D5W to be given IV over no less than 15 minutes.
  - —Hydrocortisone, a steroid, to reduce bronchial edema: 5 mg/kg can be added to the IV bottle.
- Monitor cardiac rhythm.
- Transport patients to the hospital in the position most comfortable to them.

**Bronchiolitis** is an inflammation of the bronchioles (small bronchi), caused by a viral infection in children under 2 years. Bronchiolitis is characterized by prominent expiratory wheezing and produces essentially the same symptoms as asthma. A careful history is necessary to distinguish the two, since asthma generally responds to epinephrine and bronchiolitis usually does not. Determine whether there is a family history of asthma or allergies, whether the child has any known allergies, or whether the child has had a low-grade fever. Look for evidence of infection and respiratory distress. Listen to the entire chest. Remember that wheezes caused by bronchiolitis or asthma are generalized.

The child's age can help in diagnosis. Asthma is almost never seen in children under age 1, but bronchiolitis is common in infants.

Treatment of bronchiolitis in the field should be aimed at optimizing oxygen intake. Follow these procedures:

- Give humidified oxygen by mask, and assist ventilation as necessary.
- Let the child assume a semi-sitting position with the neck slightly extended; this may be more comfortable.
- Give epinephrine (1:1000) subcutaneously in the dosage described above if bronchospasm is severe or if it is unclear whether the child has bronchiolitis or asthma.
- Be prepared to give racemic epinephrine by aerosol should it be ordered.
- Have ready a laryngoscope and endotracheal tube of the appropriate size.
- Monitor cardiac rhythm.

**Croup** (laryngotracheobronchitis) is a viral infection of the upper airways that occurs in children between 6 months and 4 years of age. It rarely occurs in older children. The infection causes edema beneath the glottis and progressively narrows the airway. The child with croup is hoarse, makes harsh, high-pitched sounds, and has a "seal bark." There is often a peculiar whooping sound on inhalation. Usually the child is found sitting very still, bolt upright in bed, and refuses to lie down. As the edema increases, the airway is further obstructed. This produces the classic signs of respiratory distress: nasal flaring, tracheal tugging, and retraction of the muscles above the sternum and between the ribs. Hypoxia, its onset signaled by restlessness, a rising pulse, and eventual cyanosis, may also occur.

Symptoms of croup usually appear following a cold or other infection. Typically, the child seems well during the day, except for some hoarseness. At night, however, a harsh, metallic cough begins that in several hours develops an alarming barking sound, which usually awakens the parents. The mild attack may subside in a few hours, but may recur for two or three nights. In the severe attack, there are obvious signs of respiratory distress.

To treat croup, concentrate on maintaining an airway and optimizing oxygen intake. Treatment should be:

- If the history is inconsistent with croup or you suspect that the upper airway is obstructed by a foreign body, examine the airway with a laryngoscope. This must be done with extreme care, because too vigorous an examination may cause laryngospasm, especially if the child *does* have croup. Note the amount of swelling and whether the cords are visible. Keep the laryngoscope and an endotracheal tube of the appropriate size nearby. If there is any possibility of epiglottitis (see below), do not examine the airway.
- Give humidified oxygen by mask. If the obstruction is severe, nebulize racemic epinephrine 0.5 ml in 2.5 ml saline into the airway with a bag-valve mask or IPPB device. To keep the child's mouth open for this procedure, use a bite block or shortened oropharyngeal airway.
- Start an IV line with D5W, using a microdrip infusion set (rate usually around 5 ml/kg/hour).
- Let the child assume the most comfortable position.
- With as little disturbance as possible, take the child to the hospital.

**Epiglottitis,** usually occurring in older children (4 and up), is caused by a bacterial infection. It is characterized by a swollen, cherry-red epiglottis that may obstruct the airway. The clinical picture of epiglottitis is almost identical to that of croup: There is pain on swallowing, frequent drooling, and sometimes an extremely high fever.

Children with epiglottitis are in danger of complete airway obstruction and should be taken to a medical facility without delay. More than half of such children require tracheostomy or intubation in the hospital. Intubation in the field is extremely dangerous and difficult and should be turned to only as a last resort.

Take these steps to treat epiglottitis:

- Administer humidified oxygen by mask.
- Start an IV line with D5W by microdrip, but do not spend much time doing this. If it is difficult to start an IV, stop trying and get the child to the hospital as fast as possible.
- Let the child assume the most comfortable position.
- Do not try to examine the epiglottis with a laryngoscope, tongue blade, or any other instrument, for severe laryngospasm and swelling may result.

## Sudden Infant Death Syndrome

Sudden infant death syndrome, or crib death, is the sudden, unexplained death of an infant, the cause of which cannot be determined by autopsy. It is the leading cause of death in infants 2 weeks to 6 months old, claiming thousands of lives annually. Crib death cannot be predicted or prevented, and usually happens while an apparently normal, healthy infant is sleeping.

Often the child is not discovered until after death. But if you arrive in time, use standard cardiopulmonary resuscitation (CPR) techniques. If the infant cannot be revived, try to help the family deal with their grief and guilt. Parents will often feel guilty due to the death's unexplained nature. In most States, the coroner must be notified of crib death. Become familiar with the laws and regulations of your State.

## Seizures in Children

Managing children's seizures is similar to managing those of adults (see Module VII). But the problem is common and alarming enough to parents to deserve reemphasis.

All the conditions that lead to seizures in adults—head trauma, meningitis, hypoxia, hypoglycemia, etc.—may also cause seizures in children. In addition, children are very sensitive to rapid rises in body temperature and are prone to develop seizures when they have fevers.

When taking the patient's history, ask the following:

- Has the child had seizures before? If so, how often? Have they always been associated with fever, or do they occur when the child is otherwise well?
- How many seizures has the child had today?
- Does the child have a history of head trauma or diabetes?
- Has the child recently had a headache or stiff neck?
- Is the child taking any medications?
- What did the seizure look like? Was it generalized or limited to one area? Did it start in one part of the body and progress? Did the eyes deviate? If so, in which direction?

The child should be examined to determine the level of consciousness and to look for evidence of fever or dehydration and signs of injury. Pay particular attention to the neurologic examination.

The single convulsion is usually self-limiting and requires no therapy other than protecting the child from injury and maintaining an airway. However, prolonged seizures or multiple seizures without a conscious interval between them (status epilepticus) are medical emergencies that should be treated:

- Place the child on the floor or on a bed away from other furniture to prevent injury. Do not try to restrain the child.
- Clear and maintain an airway. Do not try to jam a bite block between the child's clenched teeth.
- Administer oxygen. Assist ventilation with a bag-valve mask if there are periods when breathing slows or stops. Most deaths from seizures are anoxic deaths—deaths from lack of oxygen.
- Start an IV line with D5W by microdrip infusion and secure it carefully (the child may thrash or pull).
- If ordered by the physician, administer 50 percent dextrose intravenously; the usual dose is 1 ml/kg.
- Sponge the child with cool water or diluted rubbing alcohol to lower a fever. To dilute the alcohol, pour it over ice or, if ice is unavailable, use equal amounts of alcohol and water.
- Obtain an order from a physical to administer diazepam (Valium) in a dose of 0.3 mg/kg (up to a maximum of 10 mg) if the seizure does not stop. Give diazepam in a slow IV injection (1 to 3 minutes). Monitor vital signs carefully. Breath stoppage and cardiac arrest occasionally follow administration of diazepam, so have all resuscitation equipment nearby.
- Get the child to the hospital. On the way, maintain the airway and protect the child from injury.

## Battered Children

The terms "battered" or "abused" are applied to children who are deliberately injured by adults, usually a parent. Child abuse is a major problem and occurs in all socioeconomic groups. Child abuse can cause serious mental distress and physical injury—sometimes death.

The parent who abuses a child will often appear nervous, volunteering little information or giving contradictory information about the child's injury. He or she may show hostility toward the child or other parent or indifference to the child's condition, but will rarely show guilt.

Regardless of the parent's behavior, one or more of the following signs indicates that the child may have been abused:

- Multiple extremity fractures.
- Multiple bruises and abrasions, especially about the trunk and buttocks.
- Old bruises as well as fresh ones.
- Burns, especially cigarette burns or scalds (from a baby's hot bath water).
- Multiple soft-tissue injuries, or injuries about the mouth (from being force-fed a bottle).
- Evidence of poor nourishment or poor care in general.
- History of one or more suspicious accidents.
- A child who is apathetic, and who may not cry despite injuries.
- Recent visits to several emergency rooms for related complaints.
- An injury that occurred several days before medical attention was sought.

If the evidence leads you to suspect that the child has suffered abuse:

- Examine the child for abrasions, bruises, lacerations, and evidence of internal injury.
- Look for signs of head trauma, closely examining the ears and nose for blood and cerebrospinal fluid and the eyes for pupillary changes.
- Conduct the examination matter-of-factly, keeping any suspicions quiet, but make careful notes of the examination and your observations at the scene (the condition of the home or of any objects that might have been used against the child, such as belts or straps). When you get to the hospital, take your findings and suspicions privately to the physician.

It is not your responsibility to confront the parent with a charge of child abuse. Tact and discretion are essential. Any comments should be made only to the professional staff in the emergency department.

The sexually molested child is a special case and must be handled with tact and composure. The child may be frightened and upset; the parents, very anxious. Keep in mind that a parent or close relative may have been the molester. Parents may translate their feelings of guilt, helplessness, and distress into demands for action and may vent their anger and hostility on you.

Maintain a calm, understanding attitude. Explain to the child and parents that you realize that the experience has been frightening, but that it is important nevertheless for them to give a complete account of the incident. Carefully note the time, date, place, and nature of the attack and a description of the attacker. Unless there is a major injury that requires stabilization, such as a fracture, conduct a primary survey only. At least one complete physical must be conducted in the emergency room. This is likely to distress a molested child, so a quick assessment to make sure there are no injuries requiring immediate treatment is sufficient in the field. Be sure to inform the doctor in the emergency department of observations at the scene and of the patient's history. Later, you must make a carefully written record of the case, remembering that the report may become a legal document that may be used in court.

## Trauma in Children

Trauma is the leading cause of death in children age 3 and over. Trauma results from child abuse, labor and delivery, and accidents. Injuries during childbirth include skull fracture, spinal cord injury, and liver and spleen rupture. (Managing injuries that occur during birth does not differ from other injuries; just remember that they can occur and look for them in the babies you deliver.)

Accidental injuries to children most commonly result from blunt trauma and burns; penetrating injuries are rare. Trauma may injure the brain, spinal cord, thoracic structures, abdominal or pelvic organs, bones, or soft tissues. Priorities in treating accidental injuries can be remembered by the six B's: breathing, bleeding, brain, bowel, bladder, and bone.

In managing **head injuries,** the first priority is to detect and report changes in the level of consciousness and neurologic signs. Look for any widening of suture lines between cranial bones and the bulging of fontanelles (soft spots) in infants. These indicate increased intracranial pressures.

**Spinal injuries** in children are rare. However, the consequence of mismanaging spinal injury is permanent disability. Therefore, you should assume that every accident victim has a spinal injury until it is proved otherwise. The neck and back must be immobilized until spinal injury is ruled out.

**Blunt abdominal trauma** may injure either the abdominal or pelvic structures. In order of frequency, blunt abdominal trauma causes contusion (bruising), ruptured spleen, liver lacerations, and injury of the kidney, bowel, pancreas, and pelvis. Liver lacerations and splenic injuries are the most serious. Liver lacerations bleed heavily into the abdominal cavity and cause severe shock. The child with a lacerated liver usually has an enlarged abdomen (due to accumulated blood) and abrasions or bruises over the right lower rib cage or upper abdomen.

Managing suspected **liver injuries** involves treating hypovolemic shock (shock from diminished blood supply). You should:

- Establish and maintain an airway.
- Administer oxygen.
- If the child is large enough, apply and inflate the Military Anti-Shock Trousers (MAST).
- Start two or more large-bore IV lines and rapidly infuse normal saline or Ringer's solution (usually at rates of 10–15 ml/kg/hour).
- Alert the emergency department that a patient with suspected liver laceration is on the way so that a surgical team can be readied.

**Rupture of the spleen** also causes hemorrhage in the peritoneal (abdominal) cavity. Symptoms of spleen rupture include left quadrant pain into the left shoulder and tenderness with muscle guarding (tensing), decreased bowel sounds, and often fractured lower left ribs. Treat a ruptured spleen as you would a suspected liver laceration.

Hemorrhaging from **kidney injuries** is less severe and is retroperitoneal (behind the membrane lining the abdominal cavity). Only severe kidney injuries cause hypovolemic shock. Even in these cases, relatively small blood replacement (20 ml/kg) will restore the blood volume. Symptoms of kidney injuries include flank pain and tenderness and hematuria (blood in the urine). Bruises, abrasions, and a palpable flank mass may also be present. Rib fractures, however, are unlikely.

**Pelvic fractures** often cause hypovolemic shock, since they disrupt major pelvic blood vessels and may rupture the bladder. Pelvic fractures are splinted with the MAST or on some form of backboard with the child's knees slightly flexed.

**Long-bone fractures** in children differ from those in adults because children's bones are still growing at their epiphyseal plates and have thicker periosteal coverings. The epiphyseal growth plates in children are fragile and fracture easily. The periosteum, however, is very strong and often is not injured with the bone fractures. This condition—when the bone is broken, but the periosteum remains intact—is known as a greenstick fracture.

An examination of the child with a fracture will reveal swelling, tenderness, and decreased function. But because the periosteum is unharmed, the child may have more limb function than an adult with a similar fracture.

Test for **nerve and artery injury** by checking the five P's: pain, pallor, pulselessness, paralysis, and parasthenia (the abnormal functioning of tissues at odd intervals). Vascular injuries occur most frequently in distal femur and distal humerus fractures. Managing children's fractures in the field is the same as managing adults' (see Module IX).

**Burns** cause thousands of children's deaths each year. The first priority in all burns is to establish and maintain an airway. Compared with adults, children have more surface area in relation to their weight. Therefore, children suffer greater water loss after a burn. In addition, infant kidneys are less able to excrete sodium and water, making overhydration a constant danger during fluid therapy.

For these reasons, D5 ¼NS or dextrose in one-half normal saline (D5 ½NS) is recommended for fluid resuscitation. These solutions replace the larger water loss without overloading patients with sodium. Fluid resuscitation is adequate when the pulse is below 120, blood pressure is at least 90 systolic, and the child's mind is clear.

# Unit 3. Techniques of Management

## Cardiopulmonary Resuscitation in Infants and Children

The same principles govern CPR in infants, children, and adults. But CPR techniques differ with the age and size of the patient.

### AIRWAY

In the infant, extreme hyperextension of the neck may obstruct the airway. Therefore, do not tilt the head too far back. The correct position for the infant's head is shown in Figure 12.2. Place a towel under the infant's shoulders to provide the support necessary for adequate cardiac compression.

### BREATHING

When treating infants and small children, cover both the nose and mouth of the patient with your mouth. Use only small breaths. Watch the chest to determine whether ventilation is adequate (Figure 12.3). For the infant, puffs of air from the cheeks usually provide an adequate tidal volume. Ventilate once every 3 seconds (20 per minute), rather than once every 5 seconds (12 per minute) as in adults. Such adjuncts as a bag-valve mask fitted with a pediatric mask may be used, but take care not to deliver too high a tidal volume. The pocket mask, used inside out, allows more control in this case. An enriched oxygen supply may be delivered by placing the oxygen cylinder's tubing in the infant's mouth during mouth-to-mouth ventilation and by running a low flow rate (about 6 to 8 liters (l) per minute). *Do not use the demand valve when treating an infant or small child.*

### CIRCULATION

An infant's pulse can be checked at the carotid artery or over the precordium. Because an infant's or small child's ventricles lie higher in the chest than an adult's, exert external pressure over the midsternum to achieve adequate cardiac compression. Do not compress the lower sternum or xiphoid; such action may lacerate the liver. When treating infants, use only the tips of the index and middle fingers to compress the sternum one-half to three-quarters of an inch, at a rate of 80 to 100 times per minute. Ventilate once between every five compressions. When treating small children, compress the sternum three-quarters to one and one-half inches with the heel of one hand.

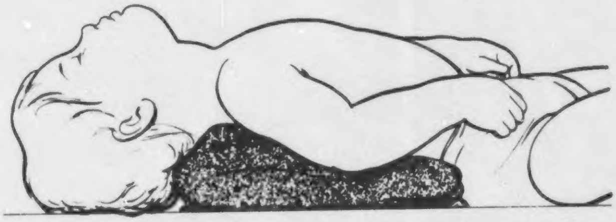


**Figure 2.** **Correct Position for Opening Infant Airway**

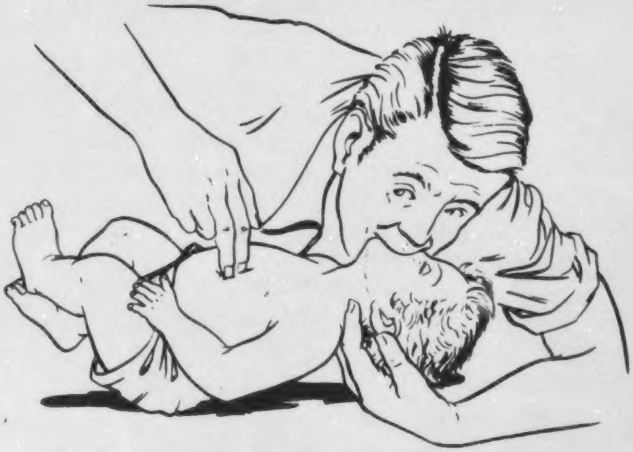


**Figure 3.** **Correct Method for Ventilating Infants**

### DEFINITIVE CPR THERAPY:

- Administer oxygen as soon as it is available.
- One member of the team should start an IV line.
- Monitor cardiac function initially with the quick-look paddles. If ventricular fibrillation is present, give the patient a countershock by placing one paddle over the right chest at the junction of the clavic and the sternum and the other paddle over the apex of the heart. Defibrillation levels based on weight are shown in Table 12.3.

Drugs used in the advanced life support of children are the same as those used in adults, and you may need to administer one or more of them. Here are their pediatric dosages:

- Sodium bicarbonate—½ mEq/kg IV push, to correct acidosis.
- Epinephrine (1:10,000)—0.1 ml/kg IV push, for asystole and to convert fine ventricular fibrillation to coarse ventricular fibrillation.
- Atropine—0.01 mg/kg IV push for bradycardia (slow heart action).
- Lidocaine—1 mg/kg IV push for ventricular tachycardia, frequent premature ventricular contractions, or recurrent ventricular fibrillation after countershock.
- Calcium chloride (10 percent)—1 ml/5 kg slow IV for some cases of asystole or electromechanical dissociation.

A more complete guide to pediatric drug dosage may be found in Table 12.4.

**Table 12.3.—Defibrillation Levels in Children**

| Type of Patient | Weight | Watt-Seconds |
|---|---|---|
| Infant | 12 | 25–50 |
| Small child | 12–25 | 100 |
| Large child | 25 | 100–200 |

## Intravenous Techniques

In this section, three methods of intravenous cannulation in children are described. The site and method depend on the patient's age and on local medical preferences. After consulting with its community's physicians, each service should establish its own protocols for this procedure.

### SCALP VEINS

Easily visible and readily accessible, an infant's scalp veins are well suited for intravenous cannulation (Figure 12.4). When performing this procedure, follow these steps:

- Gather equipment:
  - —No. 21 or No. 23 gauge winged scalp vein needle.
  - —One-half of an inch adhesive tap cut into 4- and 1-inch lengths, and 1-inch tape cut into 3-inch lengths.
  - —5-ml syringe filled with sterile saline.
  - —IV fluid (250-ml bottle or bag with microdrip infusion set) and tubing, set up and ready to be connected.
  - —Skin prep (alcohol or iodine swab).
- Prep the chosen site on the scalp with the alcohol swab, being careful not to let any alcohol run into the infant's eyes; shave off any hair in the area.
- Place a rubber band around the forehead to occlude venous return. It should not be tight enough to interfere with the arterial supply to the scalp. Palpate the vein desired.
- Attach the needle to the syringe, and flush with saline; leave the syringe attached to the needle.
- Palpate the target vein with one hand, and grasp the plastic wings of the needle with the other. Hold the needle bevel up and pierce the skin

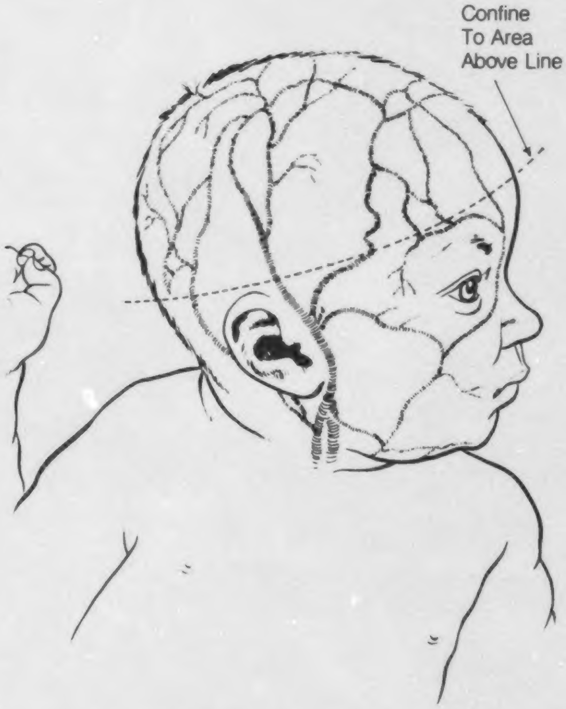


**Figure 4. Scalp Veins Used for Venipuncture**

**Table 12.4.—Guide to Pediatric Doses**

| Drug | Dosage and Administration |
|---|---|
| Sodium bicarbonate | 1–3 mEq/kg (1–3 ml/kg) per dose, slowly IV. |
| Epinephrine (Adrenalin). | For subcutaneous administration in asthma: 1:1000 0.1 ml/kg. |
| Astropine | 0.01 mg/kg IV push. |
| 2 percent lidocaine | 0.5–2.0 mg/kg per dose, slowly IV. |
| Morphine sulfate | 0.1–0.2 mg/kg intramuscularly or slowly IV. |
| Calcium chloride (10 percent). | 1 ml/5 kg, slowly IV. |
| Norepinephrine (Levophed). | 0.1–1.0 μg/kg/minute; prepared by diluting 1 ml of a 0.2% solution in 250 ml of D5W, to yield a concentration of 4 μg/ml. |
| Metaraminol (Aramine). | 0.3–2.0 mg/kg/dose as in IV infusion; prepared by diluting 50 mg in 100 ml of fluid. |
| Furosemide (Lasix) | 1 mg/kg/dose, slowly IV. |
| Diazepam (Valium) | 0.3 mg/kg, slowly IV. |
| Naloxone (Narcan) | 0.01 mg/kg, slowly IV. |
| 50 percent dextrose | 1 ml/kg IV. |
| Syrup of ipecac | 1–2 teaspoons by mouth followed by 2–3 glasses of water. |
| Aminophylline | 2–4 mg/kg diluted in at least 10 ml D5W and given over no less than 15 minutes. |
| Hydrocortisone | 5 mg/kg drawn up in a syringe and added to the IV bottle. |

about 0.5 centimeters (cm) beyond the point of entry into the vein. Because an infant's veins are very close to the skin, a deep thrust will usually break the vein and produce a hematoma. With the needle under the skin, carefully push it into the vein. If there is a possibility that the needle is in the vein but there is no blood return, draw back very slightly on the syringe. Once good blood return is obtained, slowly inject about 1 ml of normal saline from a syringe to clear the tubing, and observe the puncture site for swelling. If swelling occurs, the IV has infiltrated. Withdraw the needle, and apply firm pressure over the site for 2 to 5 minutes.

- Tape the needle in place after obtaining good blood return and once the tubing is clear. Do not try to thread the needle in farther; if the needle perforates the wall of the vein, a hematoma will result. Place the ½- by 1-inch strip of adhesive tape over the point where the needle entered the skin (Figure 12.5A). Then loop the ½- by 3-inch strips of tape over the needle wings (Figure 12.5B). Secure the rest of the tubing with the remaining tape. Detach the syringe, and connect the IV set.
- Guard against accidental needle dislodgment by taping an inverted paper cup over the infusion site; cut a window in one side of the cup for the IV tubing to pass through.

## HAND VEINS

Hand veins are not always easy to find in small children, especially in chubby infants. Occasionally, however, there is a visible and palpable vein on the back of the hand suitable for cannulation. Usually, the same equipment used for scalp vein needle insertion is needed, although a 22-gauge over-the-needle catheter can be substituted for the winged needle. An armboard and tape are needed to secure the catheter and tubing (Figure 12.6).

To administer hand vein IV's:

- Restrain the arm on an armboard so that the target vein is readily accessible.
- Place a small tourniquet—again, a rubber band will do—above and near the puncture site.
- Prepare the puncture site with an alcohol or iodine swab.
- Attach a saline-filled 5-ml syringe to the winged needle on the catheter and flush.
- Pierce the skin about 0.5 cm beyond the point of entry into the vein. Advance the needle carefully into the vein until blood returns, and slowly inject 1 ml of saline to flush the line and make sure the needle has not infiltrated.
- Tape as described above, and connect the IV set.

## EXTERNAL JUGULAR VEIN

Under field conditions, successfully performing this procedure with the external jugular vein is extremely difficult, and dangerous if performed incorrectly. Therefore, its use is only to be considered as a last resort.

If no other vein is available, the external jugular vein should be cannulated using a 22-gauge over-the-needle catheter, 3 to 4 cm in length.

- Wrap the infant securely in a sheet or blanket so that the arms and legs are restrained.
- Place the infant on a table with both shoulders touching its surface and rotate the head 90°. An assistant should hold the infant in position with the head extended 45° over the end of the table.
- Palpate the vein along its whole length to become familiar with its direction (Figure 12.7). Do not discourage crying; vigorous crying distends the external jugular vein.
- Prepare the puncture site with an alcohol or iodine swab.

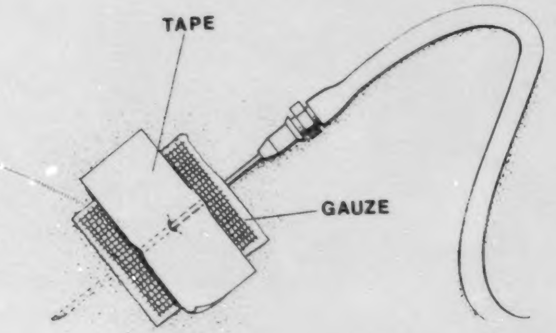


**Figure 5A. Venipuncture—Tape Placement**

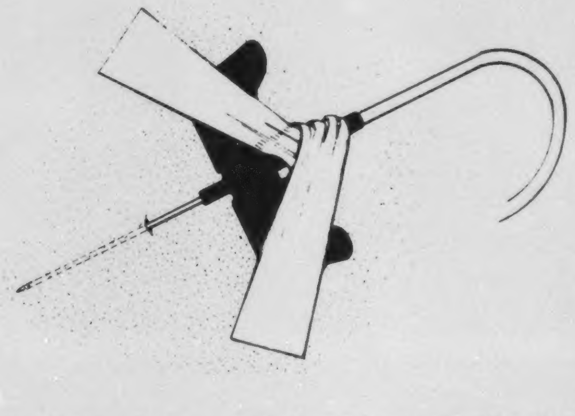


**Figure 5B. Venipuncture—Tape Loop Over Needle Wings**

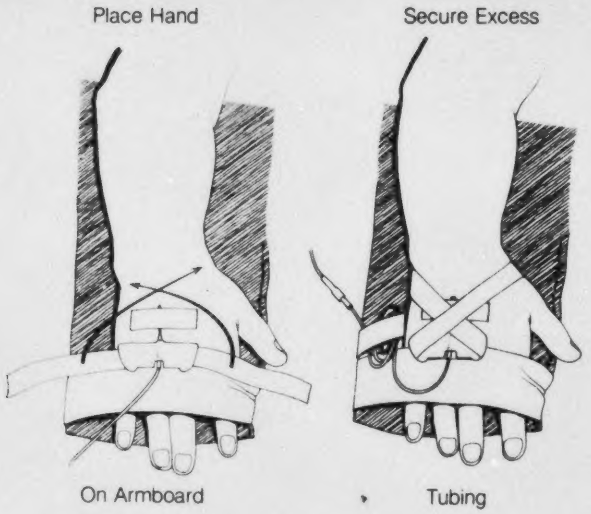


**Figure 6.** **Arm Prepared for Venipuncture of Hand Veins**

- With one hand, immobilize the vein to keep it from rolling away from the needle.
- Attach a 5-ml saline-filled syringe to the needle and flush. Keep the syringe attached. Pierce the skin about 0.5 cm beyond the site of entry into the vein. Gently advance the needle under the skin until free blood return is obtained. Carefully slide the catheter over the needle into the vein. Remove the needle and quickly connect the IV tubing to prevent air from entering the catheter. Secure the catheter firmly with tape, and do not use dressings circling the neck.
- If swelling and discoloration occur, indicating perforation of the vein, remove the needle and catheter. Apply pressure to the puncture site for 3 to 5 minutes with the child in a sitting position.

When treating children, bags or bottles used for IV fluid infusions should not exceed 250 ml in volume and should be equipped with a microdrip apparatus that controls the flow of the IV fluid. Whenever possible, a pediatric administration device should be used for delivering small, measured quantities of fluid. For maintenance fluids, D5 ¼NS at a rate of 5 ml/kg/hour is usually adequate. In shock states, dextrose in normal saline or dextrose in Ringer's solution can be run at rates of 10 to 15 ml/kg. Consult the physician for the precise rate in each situation.

## Endotracheal Intubation in Infants and Small Children

Although the principles of endotracheal intubation in infants and small children resemble those for adults, differences in anatomy and size account for some mechanical differences. First, an infant's tongue is larger than an adult's in comparison with other airway structures; and the glottis is higher, lying opposite the space between the fourth and fifth cervical vertebrae as in adults. Second, the vocal cords slant up and back behind a narrow U-shaped epiglottis. For these reasons, equipment and approach must be modified when intubating infants and small children.

- Gather equipment—
  - —Laryngoscope and blade: The blade should be straight, and the size should be determined by the size of the child (Table 12.5). In general, use the smallest blade possible. Be sure to check that the light on the blade is bright white and steady.
  - —Endotracheal tube: Select an endotracheal tube designed for use in infants and small children. Such tubes do not have cuffs—a child's airway is so small that a cuff would make the internal diameter of the tube unacceptably narrow. The size of the tube will depend on the size of the child (Table 12.6). Because it is difficult to remember all the numbers of the table, make up a similar chart and tape it to the inside of the intubation kit. A child's little finger is a good approximation of his or her trachea's size.
  - —Suction catheters that will pass the tube easily.
  - —Tape for securing the tube once it is in place.
  - —Water-soluble sterile lubricant or sterile water for lubrication.
- Preoxygenate the infant with oxygen supplementation by bag-valve mask (Figure 12.8).
- Place the infant on a firm surface with the neck flexed and the head elevated on a folded blanket. Extend the head into the "sniffing position," but

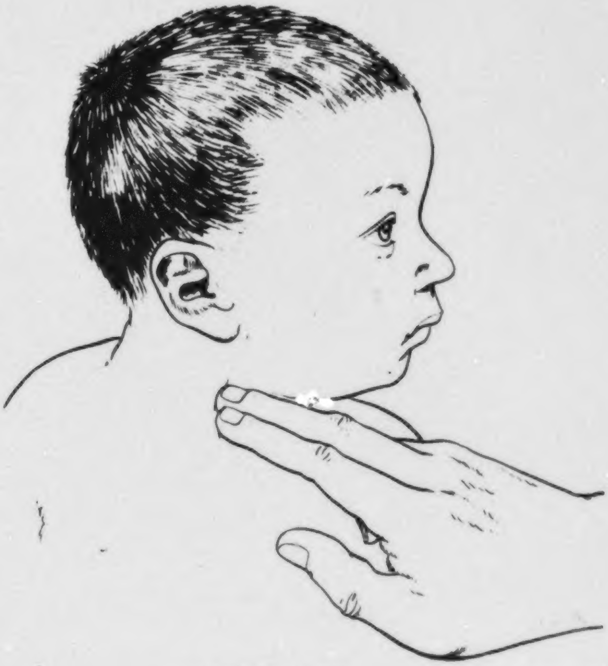


**Figure 7.** **How to Palpate Vein Prior to Venipuncture**

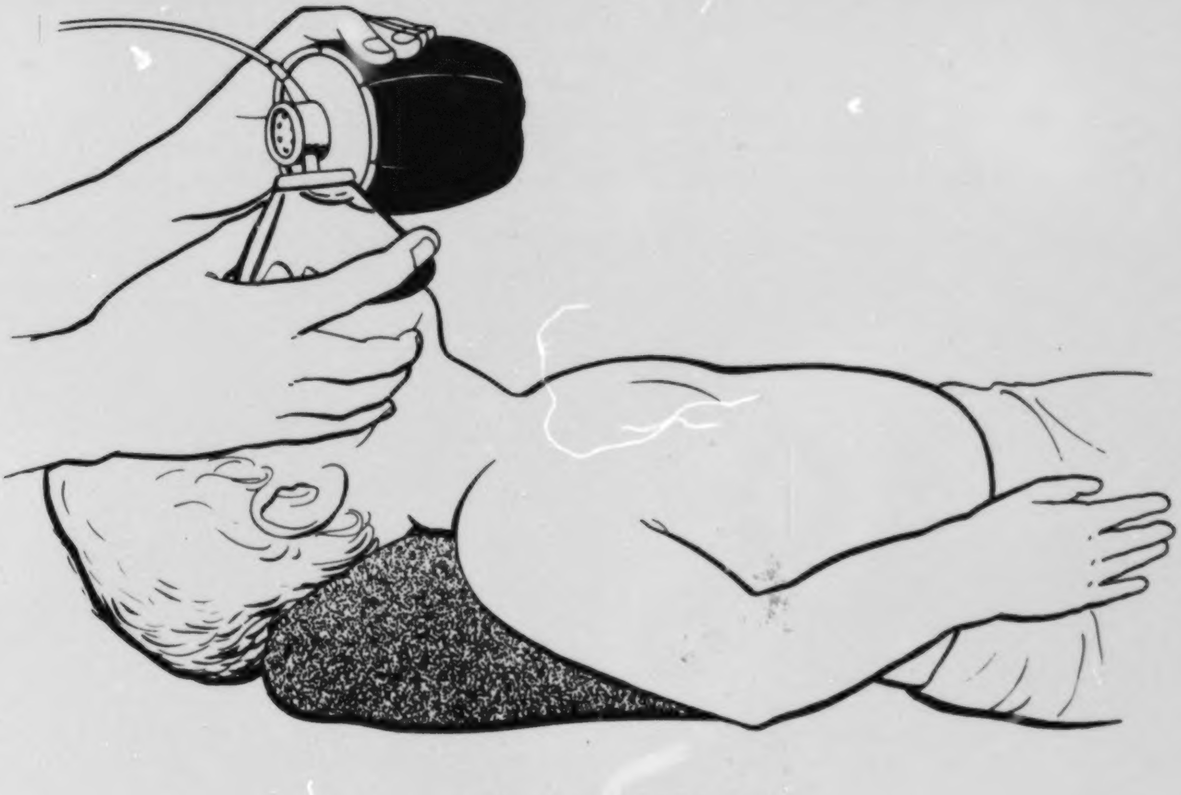


**Figure 8. Preoxygenating an infant with a Big- Valve Mask**

take care that it is not hyperextended, making the airway structures more difficult to see.

- Hold the laryngoscope handle and blade in the left hand (Figure 12.9) and insert it into the right side of the child's mouth. Carefully advance the blade. The oropharynx and the hypopharynx will come into view. Advance the tip of the blade into the vallecula, and then pull the handle upward, at a 45° angle to the floor, to elevate the tongue and jaw and bring the glottis—the space between the vocal cords—into view (Figure 12.10). Use the hand holding the laryngoscope to support the jaw, and apply light pressure to the larynx.

  Look for the cords. When they become visible, watch until they open spontaneously. Then take the endotracheal tube, hold it so that its curve is horizontal (level sideways), and insert it into the right side of the child's mouth. If the glottis is closed, wait for it to open; do not try to jam the tube through a closed glottis. Slip the tip of the tube about 5 to 10 millimeters (mm) below the vocal cords, rotating the curve of the tube into the proper plane as it is advanced. Once the tube is in the trachea, hold it firmly in place by gripping it between your thumb and index finger and pressing the middle finger against the hard palate; this keeps your hand and the tube fixed relative to the trachea so that patient movement will not jerk the tube loose. Securely tape the tube in place, and mark the point where the tube extends from the mouth so that any slippage can be detected. Check the position of the tube by watching for chest movement and auscultating both lung fields (listening for abnormal sounds) while ventilating through the tube.

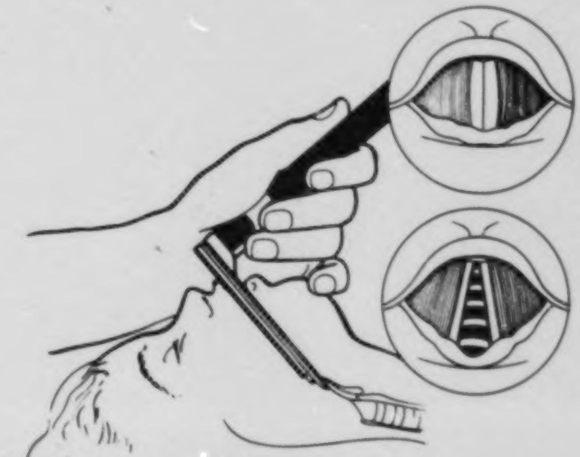


**Figure 9. Intubation of the Infant**

**Table 12.5.—Suggested Blade Size**

| Age | Blade size |
|---|---|
| Premature newborn | 0 |
| Newborn to 8 months | 1 |
| 8 months to 3 years | 1.5 |
| 3 years to 9 years | 2 |
| Over 9 years | 3 |

**Table 12.6.—Suggested Tube Size**

| Age | Internal diameter of tube (mm) |
|---|---|
| Premature newborn | 3.0 |
| Normal newborn | 3.5 |
| Large newborn | 4.0 |
| 1 month old | 4.5 |
| 1 year old | 5.0 |
| 2 to 3 years | 5.5 |
| 4 to 5 years | 6.0 |
| 6 to 9 years | 6.5 |
| 10 to 12 years | 7.0 |
| 14 years and over | 7.5 |

## Unit 4. Neonatal Transport—An Optional Skill

Transporting high-risk or critically ill newborn babies requires specialized skills and thorough training in a neonatal intensive care unit. It is beyond the scope of this text to provide all the information needed for neonatal transport. Should you become involved in the transport of high-risk neonates (newborns), you will receive additional hospital-based training under the supervision of qualified pediatricians and neonatal intensive-care nurses. This unit will deal with some basic problems and procedures in neonatal transport.

New, sophisticated techniques for the care of full-term and premature infants has significantly reduced the morbidity and mortality among high-risk newborns in hospitals whose facilities allow the practice of these techniques. The average community hospital cannot, however, provide the specially trained doctors and nurses and the expensive equipment needed for such care. Therefore, it often becomes necessary to transfer the critically ill infant to a regional center, where specialists and specialized equipment are available. The survival of such infants depends largely on their management during transport. Management conducted by a stable medical transport team skilled in neonatal intensive care is best. In several areas of the country, successful teams of nurses and EMT-P's now exist.

A well-organized regional referral system arranges for transport of the high-risk neonate after these steps are taken:

- A request for transport is made by the physician at the referring hospital. Until the transport team arrives, a physician in a specifically designated regional control center or one from an intensive care nursery gives the referring physician advice on management of the infant.
- Transportation that allows the shortest possible travel time and provides the infant with the most appropriate care en route is chosen. This can be ground transportation, helicopter, or airplane, depending on the distance, availability of services, and weather conditions.
- The transport team is mobilized, and necessary equipment is assembled. Although it is unnecessary to describe all the equipment involved, it may be helpful to touch on the incubator. Because it helps to maintain the infant's body temperature, a good incubator is critical to the neonate's survival. A fall in body temperature will start a vicious cycle of respiratory depression, hypoxemia, acidosis, further respiratory depression, and further hypoxemia, which can be fatal. The ideal transport incubator should provide:

—A neutral thermal environment.

—Easy access to the infant for intensive care, including assisted ventilation.

—Means for the monitoring of heart rate, the oxygen breathed, core or skin temperature, and blood pressure.

—A fail-safe humidified oxygen/air delivery system with a 3-hour capability.

—Adequate lighting under all conditions.

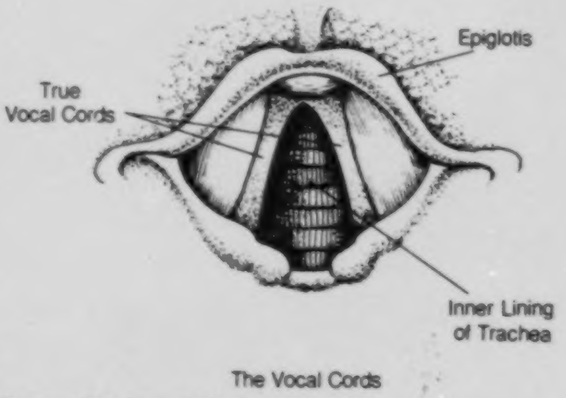


**Figure 10. Vocal Cords**

- —Portable light-weight rechargeable power units that can operate heating, lighting, and monitoring systems for 3 hours.
- —A means of safely stabilizing the infant during sudden changes of speed or altitude.

- The infant is stabilized by the transport team at the referring hospital before transport begins. Such conditions as hypoxemia, acidosis, hypoglycemia, and hypovolemia must be treated before the infant leaves the referring hospital. Since stabilization may require several hours, the transport team must be prepared to spend a good deal of time on each case. In addition to stabilizing the infant, the team must obtain:
  - —Copies of the mother's and infant's charts.
  - —Any x-rays of the infant.
  - —The names of the infant, parents, and referring physician and a phone number where the parents can be reached.
  - —Specimens of the maternal and umbilical cord blood.
  - —A consent form indicating that the parents authorize the transfer.

Transport can begin as soon as the infant is stabilized. The receiving hospital is then notified of the estimated time of arrival and a detailed transport record is started.

## Glossary

**Acidosis:** A disturbance in the acid-base balance of the body caused by excessive amounts of carbon dioxide (respiratory acidosis) or lactic and organic acids (metabolic acidosis); characterized by a pH of less than 7.35.

**bronchiolitis:** A condition seen in children under 2 years old; characterized by dyspnea and wheezing.

**bronchoconstriction:** Narrowing of the bronchial tube.

**bronchodilator:** An agent that causes the dilation of the bronchioles.

**crib death:** Another name for sudden infant death syndrome—the sudden unexplained death of an infant. The cause is unknown.

**croup:** A viral infection of the upper airways that occurs in children between 6 months and 4 years of age.

**epiglottitis:** A bacterial infection of the epiglottis, usually occurring in children over 4 years old and characterized by a swollen cherry-red epiglottis that may obstruct the airway.

**epiglottis:** The lidlike cartilaginous structure overhanging the superior entrance to the larynx and serving to prevent food from entering the larynx and trachea while swallowing.

**glottis:** The vocal apparatus of the larynx, consisting of the true vocal cords and the opening between them.

**hematoma:** A localized collection of blood in the tissues resulting from injury or a broken blood vessel.

**hypercarbia:** An excessive amount of carbon dioxide in the blood; a carbon dioxide pressure greater than 45 to 50 torr.

**hyperresonance:** Abnormally increased resonance to percussion.

**hypoxemia:** Inadequate oxygen in the blood; an arterial oxygen pressure of less than 60 torr.

**infiltration:** The deposit of fluid into the tissues often occurring as a result of administering fluid through an IV cannula that has penetrated the opposite wall of the vein.

**laryngoscope:** An instrument used for examining the larynx and its related structures.

**oropharynx:** The area behind the base of the tongue that lies between the soft palate and the upper portion of the epiglottis.

**seal bark:** Characteristic hoarse, barking cough heard in croup.

**sniffing position:** Position for endotracheal intubation with the neck flexed and the head extended.

**status asthmaticus:** A severe prolonged asthmatic attack that cannot be broken with epinephrine.

**status epilepticus:** The occurrence of two or more seizures without any period of complete consciousness between them.

**stridor:** The harsh, high-pitched respiratory sound associated with severe upper airway obstruction, such as laryngeal edema.

**transtrachea jet insufflation:** An emergency ventilation technique that utilizes the high-flow, high-pressure jet principle to deliver oxygen to the patient through the trachea.

**wheezes:** The high-pitched whistling sounds characterizing obstruction or spasms of the lower airways.

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## Module XIII.

# Management of Emotional Crisis

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# Module XIII.

# Management of Emotional Crisis

## Unit 1. Emotional Aspects of Illness and Injury

All those involved in a critical illness or an injury—patient, family, bystanders, and health professionals—respond to the natural stresses that occur in such emergencies. Emergency Medical Technicians-Paramedics (EMT-P's) can deal effectively with emotional responses—in others and in themselves—only if they can understand and anticipate them.

### Responses of Patients to Illness and Injury

Patients react to injury or critical illness in ways largely determined by mechanisms they have already developed for dealing with stress. These reactions generally follow common patterns. When an accident or an illness strikes, patients usually experience painful or unpleasant sensations. They occasionally experience decreased strength or energy.

The common response to this is anxiety. Some patients may deny or minimize their symptoms, while others may grow irritable and angry. The effective paramedic is alert to the following reactions once patients perceive themselves as being ill or injured:

- *Realistic fears.* Patients may fear pain, disability, death, or financial problems. Such fears are normal and reasonable.
- *General anxiety.* Feelings of loss of control are common among ill or injured patients. They may feel helpless in knowing that they are completely dependent on someone else, often a stranger, whose experience in medical care and whose ability they cannot evaluate easily. Patients whose self-esteem depends on their being active, independent, and aggressive are particularly prone to anxiety in these situations.
- *Regression.* Patients may return to earlier or more primitive behavior patterns, and their actions may appear childlike. Because ill or injured patients, like children, must depend on others for their survival, this is a natural reaction.
- *Depression.* Depression is a natural response to the loss of some bodily function and to the feelings of loss of control over one's destiny.
- *Denial.* Because it causes them anxiety, many patients try to deny or ignore the seriousness of their illness or injury, dismissing all symptoms with words like "only" or "a little." When a patient uses this mechanism, try to find an informant among the patient's family or friends from whom a more accurate history can be obtained.
- *Displacement of anger.* Patients often respond to discomfort or limitation of activity by becoming resentful and suspicious. They may vent this

anger on the paramedic by becoming impatient, irritable, or excessively demanding. Remember that the patient's anger stems from fear and discomfort, not from anything you have done.

- *Confusion.* Illness or injury can cause disorientation, especially among the elderly. Such confusion is increased by the presence of unfamiliar people and equipment. Explain carefully to the confused patient who you are and what you plan to do. Explain the treatment as it is being performed.

While the above list should be helpful, paramedics are cautioned not to spend an inordinate amount of time in "reaction diagnosis." Put your priority on diagnosing and treating the illness or injury.

Patients usually feel uncomfortable about being examined. Ordinarily, one is undressed in front of another person only in situations of trust or intimacy. Almost every patient will feel some anxiety about having a stranger perform a physical examination. Some patients may even consider the physical exam a humiliating invasion of privacy. Try to establish a relationship with the patient during an initial interview before conducting the physical examination. Be very sure that the unclothed patient is properly draped or shielded from the stares of curious bystanders. Conduct the examination in an efficient, businesslike manner and talk with the patient during the entire procedure.

## Responses of the Family, Friends, or Bystanders

Those at the scene with the patient may also show many of the responses described above. Family members and friends may be anxious, panicky, or angry. A bystander's anger often results from feelings of guilt. To cope with their own anxiety, nonprofessionals at the scene may demand immediate action or pressure the paramedic to move the patient to a hospital before the appropriate examination and stabilization have been completed. Loved ones may state or imply that the paramedic is not competent enough to handle the situation ("Get him to the hospital so he can be seen by a real doctor").

A paramedic must accept the concern of the patient's family and friends and realize that their behavior, no matter how irritating, arises from distress. Remain calm and sympathetic. Explain the patient's treatment to any friends and family members. Reassure them that you are at all times in radio contact with physicians and are acting under their direction.

## Responses of the Paramedic

Health professionals are not immune to the stresses of emergency situations themselves. When dealing with the critically ill and injured, EMT–P's can experience a wide range of emotions, not all pleasant: The paramedic may become irritated by the demands made by the patient or bystanders; anxious when faced with life-threatening injuries; defensive when someone implies that he or she is ill-prepared to handle emergencies; and sad when confronting tragedy.

Although these feelings are natural, it is best that you not express them during an emergency. Your appearance of calmness and confidence will help to relieve others' anxiety, and thus is an important, if sometimes overlooked, part of the paramedic's therapeutic role.

Anxiety, defensiveness, and grief may be excusable lapses in the confidence a paramedic should display; but beware of showing irritation with the patient who does not appear particularly ill. This reaction is common among emergency personnel, who, being prepared to deal with life-and-death problems, may regard seemingly minor complaints as burdensome and annoying. Remember, however, that most people call for emergency help only if they believe there is an emergency. Patients worry about injuries, pains, disturbing feelings, and bodily functions that they believe to be abnormal. It is not up to you to judge the validity of such complaints, which after all are real to the patient. What is important is what is perceived. Although it is more dramatic to rescue the multiple-trauma victim than to reassure the patient with a headcold, both of them are distressed and need help. In both cases, you must be supportive and nonjudgmental, rendering whatever care is needed. How the patient perceives the problem, regardless of how illogical it appears to observers, must govern your response.

## Responses of Patients and Bystanders to Mass Casualties

When there are multiple casualties—as in an automobile accident claiming several victims or a natural disaster—both victims and bystanders may become dazed, disorganized, or overwhelmed. The American Psychiatric Association has identified five possible reactions in such situations:

- *Normal reaction.* When confronted with multiple casualties, most people react with extreme anxiety, including sweating, shaking, weakness, nausea, and sometimes vomiting. Those who respond this way can recover completely within a few minutes and, if given clear instructions, be of help.
- *Blind panic.* The individual's judgment seems to disappear completely, and he or she may commit irrational, foolish, or unsafe acts. Blind panic is particularly dangerous because it may lead to mass panic.
- *Depression.* The individual who remains motionless and looks numbed or dazed is depressed. Give such a person a task to perform in order to bring him or her back to reality.

- *Overreaction.* The person who talks compulsively, jokes inappropriately, and races from one task to another while accomplishing very little is overreacting to a situation.
- *Conversion hysteria.* The person shifts moods rapidly, from extreme anxiety to relative calmness, while converting anxiety to some bodily dysfunction. This reaction can result in hysterical blindness, deafness, or paralysis.

Observe the following guidelines when dealing with mass casualties:

- Identify yourself and take command of the situation. Strive to remain self-assured and sympathetic while conducting yourself in a businesslike manner.
- Treat serious physical injuries immediately. Reassure anxious patients or bystanders.
- Keep spectators away from the patients, but do not leave alone someone showing an emotional reaction. If all rescue personnel are busy dealing with physical injuries, assign a responsible bystander to stay with anyone who is acting unusual.
- Assign tasks to bystanders to keep them occupied. Feeling that one is useful and responsible greatly lessens a person's anxiety.
- Bystanders and the walking wounded should be removed from the area being used for life support intervention as soon as possible.
- Respect patient's rights to their own feelings. Let them know that you are trying to understand them—don't tell them how they "should" feel.
- Fear and panic can be as disabling as physical injuries, and some people are able to deal with anxiety better than others. Accept a patient's physical and emotional limitations. Do not try to force patients to deal with more than they seem able to cope with, but help them recognize and use their remaining strength and do what you can to lessen their anxiety. Stabilizing persons in a crisis makes emergency medical care more effective.
- Use sedatives only as a last resort: In most cases, they only add to the patient's confusion, and they may mask important physical symptoms. A calm, reassuring attitude is better, more effective therapy.
- Accept your own limitations. Particularly when there are mass casualties, there is only so much one person can do; you will provide more effective care by establishing priorities and not overextending yourself.

### Death and Dying

A paramedic's contacts with the dying will usually be confined to the seriously ill or injured patient who is slipping in and out of consciousness. Occasionally, however, you will encounter dying patients who are conscious and aware of their condition. Although everything possible should be done to attend to a dying patient's physical needs, do not neglect emotional and religious needs. Paramedics can to some degree reduce the apprehension of the dying by being as reassuring as possible. Tell the patient that every effort is being made to get her or him to the hospital, where expert help is available.

Many dying patients will ask to talk with their families. You may be able to reduce their anxiety by offering to convey any important messages. Such communications, since they may later have legal implications, should be noted carefully. The families and friends on the scene who are aware that the patient is dying should be reassured that everything possible is being done to save the patient.

Paramedics must master their own feelings in the face of death. Contact with dead and dying patients grieves all health professionals. If you are aware that everyone has such reactions, there will be less chance that your own sadness will affect how you treat your patient.

## Unit 2. Psychiatric Emergencies

Psychiatric emergencies are those situations in which patients display disorders of mood, thought, or behavior that are dangerous or disturbing to themselves or others. Almost all disturbed behavior represents the individual's effort to cope with internal or external stress—anxiety. Such behavior often disappears when normal psychological defense mechanisms are properly mobilized.

Most psychiatric emergencies are emergencies because the patients' disturbed behavior makes them, their families, or bystanders anxious or panicky. Patients and others will feel that events are out of their control, and they may demand that paramedics "do something" immediately. Remember that the general excitement in such situations results from feelings of fear and loss of control. These feelings can be lessened if the EMT–P maintains a calm, self-assured attitude.

*Abnormal behavior may be due to conditions other than mental illness.* Diabetes, seizure disorders, severe infections, metabolic disorders, head injuries, hypertension, stroke, alcohol, and certain drugs all may cause disturbed behavior. In more than half of all psychiatric emergencies, drunkenness or a drug-induced "freak- out" caused the disturbed behavior. Keep this in mind whenever you evaluate a patient who apparently has an emotional disturbance.

Primary emotional crisis is a normal response to personal crisis. When individuals' basic needs are threatened, they face crises that vary in severity depending on their ability to deal with their feelings. People in crisis can face the situation in two ways: Either they can try to cope with it, or they can try to escape from it. Escape takes many forms—the use of alcohol or other drugs, suicide, or the manifestation of psychiatric symptoms. Such symptoms are a compromise for the patient; they reduce the anxiety produced by the inner crisis.

## Patient Assessment and General Principles of Management

The patient exhibiting bizarre or unusual behavior is usually suffering an emotional crisis and may need immediate attention. While trying to ease the patient's distress, you must prevent injury to the patient or anyone else at the scene and should attempt to bring a measure of calm to a stressful situation.

The indepth counseling necessary to deal with a severe psychiatric reaction will not be feasible in the field. In some cases, a crisis worker (contacted through the appropriate local resources) may be more effective than the paramedic. Ideally, if an emotional problem is anticipated, the dispatcher can contact the appropriate crisis intervention team before the emergency medical services (EMS) team arrives at the scene. However, if the EMS team arrives at the scene without prior warning, you must be prepared to deal with the situation as well as your training and the circumstances allow. As soon as it becomes clear you are facing a psychiatric emergency, notify your dispatcher and contact the appropriate crisis intervention team.

The patient-assessment and principles-of-management sections of this unit are presented together because the two are inseparable when dealing with emotional problems: The process of obtaining a patient history is itself therapeutic.

When dealing with emotionally disturbed patients, you must:

- Be prepared to spend time with the situation. A lengthy, unhurried discussion may be required to provide the patient with emotional relief. Such individuals need dispassionate, concerned attention.
- Be calm and direct. Disturbed patients are often frightened that they have lost or are losing their self-control. Remain calm and undisturbed, thus showing the patients that you are confident that they can stay in control. Indeed, one major purpose of the interview is to help a patient regain control. Showing anxiety or panic serves only to increase a patient's belief that the situation is overwhelming.
- Clearly identify yourself. Explain to the patients the purpose of the EMS crew and what it is trying to do for them.
- Assess the patients wherever the emergency occurs, rather than immediately rushing off to the hospital—a place that is strange and intimidating even for patients who are not in emotional crisis. Hurrying to the hospital can also reinforce the belief that something is terribly wrong. Let patients recover their bearings in familiar surroundings.
- Interview the patients alone, if possible. Ask relatives or bystanders to go into another room, where another EMT-P can obtain their stories.
- Sit down when interviewing patients. Never tower over them.
- Let the patients tell what happened in their own way. Do not attempt to direct the conversation, but allow the patients to air their feelings.
- Be interested in the patients' stories, but not overly sympathetic. If you overwhelm a patient with pity, you will convince the patient that the situation is indeed hopeless. Treat a patient as someone who is expected to get better.
- Be nonjudgmental. Accept the patients' right to have their own feelings and do not blame or criticize them for feeling as they do.
- Provide honest reassurance. Let the patients know what is expected of them and what they can expect of you.
- Present a definite plan of action. This makes patients feel that you are doing something to help and relieves their anxiety. People in crisis need direction. Do not confront patients with questions ("Do you want to go to the hospital?"); rather, use statements ("I think it is important for you to go to the hospital. There are doctors there who can help you").
- Encourage purposeful movement; this often helps relieve anxiety. If patients will be going to the hospital, encourage them to gather up the belongings they want to take with them. Letting patients do as much as possible for themselves can reinforce their feelings that you expect them to get better.
- Stay with the patient the whole time. Having responded to the emergency, you are responsible for the patient's safety.
- Never assume you cannot talk with a patient until you have tried.

Patient assessment begins as soon as you start conversing. First, take note of the patient's clothing. Is the patient neat or disheveled in appearance? What is the patient's rate of speech? If it is slow, this may suggest depression or intoxication; if rapid and pressured, mania or the presence of amphetamines. Keep the following questions in mind as you make your assessment:

- Is the patient easily distracted?
- Are the patient's responses appropriate?
- Is the patient alert and coherent?
- What is the patient's mood—does the patient seem abnormally depressed, elated, agitated, fearful, or worried?
- Does the patient show evidence of disordered thought, such as disturbances in judgment, delusions (false ideas), or hallucinations (seeing or hearing things that are not there)?

Your initial questions should be direct and specific; your goal is to establish whether the patient is alert, oriented, and able to communicate. Only information that is crucial to immediate management should be collected. You should also get the patient's full name, age, and marital status; find out what kind of work the patient does, and where and with whom the patient lives; and inquire about past medical and psychiatric problems.

After the initial inquiry, questions should be open-ended, beginning with words like "what," "how," or "when." Try *not* to begin with "why" (as in, "Why did you lock everyone out of your room?"). The patient may perceive "why" questions as being criticism. Let all patients tell their own stories in their own way.

After talking with the patients and gaining their confidence, gauge each patient's ability to tolerate a physical examination. When feasible, check the patient's vital signs and perform a quick neurological examination. (This may not be possible with violent or extremely fearful patients.) Do as much as you can without increasing the patient's distress. Keep talking to the patient throughout the physical examination.

In general, a seriously disturbed patient should be seen by a physician, who can decide whether hospitalization is necessary. In most areas, there are four ways to admit patients for psychiatric care. First is "voluntary admission," in which patients sign themselves into the hospital and can leave whenever they want to. Second is "voluntary commitment," in which patients agree to be admitted to the hospital but cannot leave until their commitment period ends. Voluntary commitments usually last 10 to 30 days, unless the patients extend the commitment.

A third alternative exists, for handling patients who will not go willingly to the hospital. Such patients can be involuntarily detained and brought to the hospital by the police or family members. During this "emergency detention," the patient is examined by a psychiatrist. If the psychiatrist feels that the patient is dangerous, she or he can authorize hospitalization for a short time, usually about 10 days. In some areas, the psychiatrist, before obtaining permission for an emergency detention, must prove to the county mental-health authorities that the patient needs to be admitted to the hospital.

Finally, many States have a fourth procedure, known as "court commitment," in which the psychiatrist must testify in court that the patient is mentally ill and needs treatment. Some States also require that patients must first be declared dangerous to themselves or others before they can be committed against their will.

Because involuntary commitment deprives people of their civil liberties, it should not be undertaken lightly. It is not always easy, even for an experienced psychiatrist, to determine just when a patient's behavior justifies removal from society and when that behavior presents a danger to the patient or others. The laws on involuntary detainment vary considerably from State to State, so you must become familiar with the laws in your community. In general, patients who are conscious and alert can be taken to the hospital only with their consent. If they do not consent, patients can be taken to the hospital only at the request of the police. The same applies to forcible restraint. When these measures are necessary, law enforcement officers must be called. Each ambulance service should have clearly defined protocols for dealing with patients needing involuntary commitment.

## Specific Psychiatric Emergencies

The psychiatric emergencies that you are likely to encounter as a paramedic include depression, suicide, violent behavior, paranoia, anxiety and phobias, disorganization and disorientation, and drug or alcohol addiction.

### DEPRESSION

Depression can lead to a psychiatric emergency such as suicide and may cause other psychological disorders. Depressed patients can be recognized by their sad appearance, crying spells, and listless or apathetic behavior. They feel worthless, guilty, and extremely pessimistic. Asserting that no one understands or cares about them and their problems cannot be solved, they often express the desire to be left alone. Their speech may be halting and retarded, as if they have hardly enough energy to talk. If able to give a history, they may report that they awaken at 3:00 or 4:00 a.m. and cannot go back to sleep. Also, they may say that they feel bad in the morning and that they improve during the day.

Some depressed patients, however, do not feel like talking. In such cases, it may help to confront the patients with your own observations. Such a comment as "You look very sad" often encourages patients to talk about their depressed feelings. Such patients may burst into tears. Do not discourage their crying. Maintain a sympathetic silence and let the patients "cry themselves out."

Every depressed patient should be questioned directly about suicidal thoughts. You might ask, for example, "Have you ever wished that you were dead or thought about killing yourself?" If the response is yes, ask the patient how he or she would do this and determine whether the patient has made any concrete plans for suicide. Evaluating the seriousness of suicidal intentions in this way can help you decide whether the patient needs to be hospitalized.

Depressed patients need sympathetic attention and reassurance. They need to know that the paramedic is concerned about them. It usually is best if a single member of the rescue team interviews these patients in private, as the presence of several people may make depressed patients uncomfortable. Patients should be told that though many people have periods of unhappiness, they can be helped to feel better. At this point, you can mention community sources where such help can be found.

## SUICIDE

Suicide is defined as any willful act designed to end one's own life. It is most common in men, especially those who are single, widowed, or divorced. Suicide also occurs more frequently in depressed persons and alcoholics. At least 60 percent of all suicide victims previously attempted suicide, and 75 percent gave clear warning that they intended to kill themselves. Typically, a suicide attempt will occur when an individual's close emotional attachments are in danger or when he or she loses a significant family member or friend. Suicides often feel unable to manage their lives. Frequently, they lack self-esteem.

*Every suicidal act or gesture should be taken seriously, and the patient should be evaluated by a psychiatrist.*

Many suicides will make last-minute attempts to communicate their intentions. When an individual phones to threaten suicide, someone should stay on the line with that person until the rescue squad reaches the scene. When the EMS team arrives, the area should be surveyed quickly for instruments that a suicide might use to cause self-injury. Discreetly remove any dangerous articles. Talk quietly with the patient. Encourage the patient to discuss the situation. Do not be afraid to ask directly about suicidal thoughts. Find out the following: Has there been a previous suicide attempt? Have any concrete plans concerning the method of suicide been made? Has any family member ever committed suicide?

Patients who have made previous attempts, who have detailed suicide plans, or whose close relatives have attempted suicide are most likely to attempt to kill themselves. These patients must be reassured and brought to the hospital. They must not be left alone under any circumstances.

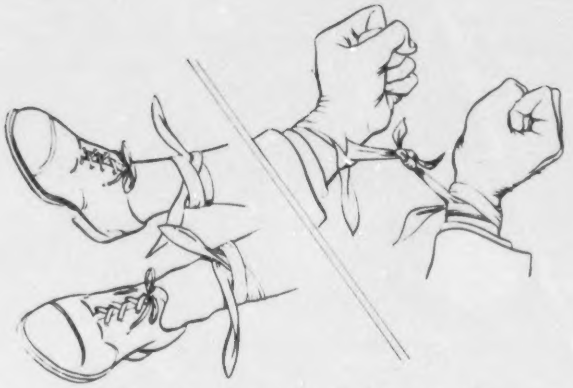
When patients attempt suicide, their *medical* treatment has priority. Drug overdoses must be managed for possible respiratory depression or circulatory collapse. Patients with slashed wrists must have their bleeding controlled. Even under these circumstances, you should try to talk with the patients, if they are conscious, and encourage them to speak about their situation. When dealing with drug overdoses, collect any medication containers, pills, or other drugs found on the scene and bring the items to the emergency department with the patients.

*Rage, hostility, and violent behavior.* The angry, violent patient is ready to fight with anyone who approaches and may be difficult to control. Remember that anger may be a response to illness and that aggressive behavior may be the patient's way of coping with feelings of helplessness. Avoid responding with anger and defensiveness. If there is a possibility of danger, interview the patient in the presence of another EMT. Violent patients should be told briefly and honestly what they can expect from the paramedic and what the paramedic expects from them. Many angry or violent patients can be calmed by a trained person who appears confident that the patient will behave well. Encourage the patients to speak directly about the cause of their anger. A statement such as "I'm not sure I understand why you are angry" often brings results. Reassure the patients that you are there to help them and not to punish them for their violence or anger. Tell them that talking with a doctor will help them feel better.

A patient who is violent and out of control presents more difficulty. Even if the paramedics are allowed to take patients to the hospital against their will, two or three paramedics might not be enough to subdue a patient who is out of control. Notify the police if you are unable to communicate with patients who are dangerous to themselves or others. Remember that the EMT crew can transport only those patients who request treatment or whose transport is authorized by the police.

Restraints, which also require police authorization, may be needed when taking a violent patient to the hospital against his or her will. Restraints should be padded so that they will not injure patients who struggle against them. When applying restraints, always explain what you are doing, even if the patient does not appear to be listening. Tell patients that the restraints are to protect them and others from injury. To restrain a violent patient:

- Put the patient on his or her back (assuming there are no injuries).
- Apply one cravat to each wrist and ankle with a clove hitch, as illustrated in figure 13.1.
- Tie the wrists and ankles together with two or more cravats.
- Secure the tails of the extremity cravats to opposite sides of the stretcher frame.
- Secure the body with two or three straps placed around the chest, waist, or upper legs. Make sure



Application of Cravats Using Clove Hitches

**Figure 1. How to Restrain a Violent Patient's Wrists and Ankles**

that none of the straps will constrict the patient's breathing or be unduly tight.

Once restraints are applied, they must not be removed en route. Do not bargain with patients. Never agree to remove restraints in exchange for a patient's good behavior.

If a potentially violent patient is transported without restraints, make sure that the patient is lying down and is watched at all times. The paramedics should position themselves between the patient and the door in case a rapid exit becomes necessary. Unrestrained patients who become dangerous en route should be restrained.

If a patient is potentially homicidal, do not attempt restraint. In such situations, the paramedic is responsible only for contacting the police and removing bystanders from the scene.

## PARANOIA

Paranoid patients are suspicious and distrustful. Hostile and uncooperative, they suffer from the delusion that people are out to get them. Paranoid patients tend to brood over real or imagined injustices, to carry grudges, and to recall wrongs done them years before. Many are excitable and unpredictable and have outbursts of bizarre or aggressive behavior. Their personalities often provoke dislike and anger in others.

When dealing with paranoid patients, always identify yourself clearly and explain what you are trying to do. The paranoid may be suspicious of warmth and reassurance, so maintain a friendly but somewhat distant neutrality.

- Avoid becoming angry at the patient's anger.
- Behave consistently.
- Agree or disagree with the paranoid patient's statements honestly.
- Use tact and firmness to persuade the patient to go to the hospital.
- Gain the patient's confidence by showing authority, self-assurance, and a genuine desire to help.

But *do NOT:*

- Go along with the delusions of such patients in order to pacify them.
- Interview family or friends in the patient's presence. Taking a relative aside and speaking in hushed tones only reinforces the paranoids' delusion that people are plotting against them.

## ANXIETY AND PHOBIAS

Patients having anxiety attacks show evidence of intense fear. Tense and restless, they often wring their hands and pace. They often suffer from tremors, tachycardia (rapid heartbeat), dyspnea (difficult breathing), sweating, and diarrhea. These patients feel overwhelmed and cannot concentrate. Sometimes they will hyperventilate and develop all the symptoms of that syndrome, including dizziness, tingling around the mouth and fingers, and carpopedal spasms (spasms of the hands and feet). Their behavior creates anxiety in those around them as well, and they very possibly will be surrounded by a horde of anxious and excited people when the EMS crew arrives.

The first step in managing such patients is to separate them from the excited people around them. Identify yourself and tell these patients clearly and confidently, being firm but supportive, that effective treatment is available for their problems. Explain what you are doing and do not leave the patients alone. En route to the hospital, continue to issue reassurances.

Patients with phobias focus all their anxieties in the form of intense fears. Phobic reactions include intense fears of high places, enclosed places, animals, weapons, and public gatherings. Patients' anxiety becomes unbearable when they are confronting the feared situation. When dealing with phobic patients, you must explain carefully each step involved in transporting the patient to the hospital and go through each step in detail beforehand ("Then we will walk down the stairs, and I will hold your arm; then we will get into the back of the ambulance. You will sit on a bench in the ambulance, and I will be beside you"). Repeat each description as the action occurs ("Now we are going down the stairs"). Such explanations will help to lessen these patients' fears.

## DISORGANIZATION AND DISORIENTATION

Disorganized patients are characterized by uncontrolled, disconnected thoughts. Their speech is usually incoherent or rambling, even though they may be oriented to person and place. Often such patients are found wandering aimlessly down the middle of a street, dressed peculiarly and uttering meaningless words and sentences. Such patients need structure. Explain what will be done and exactly what the patient will be expected to do. Simple, consistent, firm directions should be given. It may be impossible to get a detailed history, but try to obtain the patient's name and address. These patients can be told that they need to see a doctor and that the EMS crew is planning to take them to a hospital where they can be helped.

Disoriented patients commonly do not know where they are or what day it is; they may not even know their names. This disturbance is more common among the elderly, who may lapse back into memories and behave as though they were living in their pasts. Disorientation also can result from physical problems, including head injury, alcohol or other drug ingestion, and such metabolic disorders as diabetes. Try to keep disoriented patients aware of the time, place, person, and situation. You may have to repeat several times en route who you are and what you are doing. The paramedics should reassure patients during the trip to the hospital by pointing out orienting landmarks, etc.

### PSYCHIATRIC EMERGENCIES CAUSED BY ALCOHOL OR OTHER DRUGS

Alcohol and other drugs often cause disturbed behavior. Some aspects of alcohol and drug abuse (the terminology, alcoholic hallucinosis, delirium tremens, and drug overdose) are discussed in Module X. But now, other emergencies caused by alcohol and drug use will be discussed.

Acute intoxication occurs when an individual has consumed enough alcohol to raise his or her blood serum alcohol levels above 150 milligrams per 100 milliliters. Signs of alcohol intoxication include poor impulse control drowsiness, lack of coordination, slurred speech, and sometimes combativeness. If individuals are not combative, they should simply be allowed to sleep until the alcohol wears off. If they are combative, the physician may order chlorpromazine or paraldehyde to sedate them. Remember, however, that the person who appears intoxicated may be suffering from the effects of a more serious medical problem. These patients should therefore be checked carefully for signs of illness or injury.

Narcotic withdrawal occurs when individuals stop taking substances to which they have become physically addicted. The symptoms include restlessness, tossing in sleep, yawning, watery eyes and nose, sweating, dilated pupils, goose pimples, nausea, and vomiting. Narcotic withdrawal is usually not dangerous to otherwise healthy individuals. Patients should be transported to the hospital, where their withdrawal symptoms can be suppressed with narcotics and they can be withdrawn slowly from addicting drugs. Do not attempt to suppress narcotic withdrawal symptoms with morphine or meperidine on the scene unless so ordered by the physician, who may feel that the patient has an underlying disease that makes narcotic withdrawal particularly dangerous. Giving narcotics to addicts in the field may suggest to other addicts that they too can obtain narcotics from a paramedic.

Barbituate and sedative drug withdrawal symptoms resemble those of alcohol withdrawal. (See Module X.) *Barbituate withdrawal can be fatal.* Therefore, the physician may order the paramedic to give intravenous diazepam or phenobarbitol to suppress the symptoms until the patient feels drowsy. The total initial dose must be recorded accurately, because it determines the sedative dosage given later, during slow withdrawal in the hospital. Seizures occurring during barbituate withdrawal can cause death. If seizures should occur, treat them as such (see Module VII).

Withdrawal symptoms can also occur when patients stop taking commonly prescribed sedatives, like meprobamate, chlordiazepoxide, and diazepam. These drugs can cause withdrawal symptoms, including insomnia, anxiety, loss of appetite, vomiting, tremors, muscle twitching, and seizures. Treat seizures from sedative withdrawal just as any other seizure.

Your manner and attitude during the initial contact with the patient are the most important factors in determining later events. Your staying calm, self-confident, sympathetic, and firm can often make the difference between success and failure in handling a psychiatric emergency.

## Unit 3. Techniques of Management: Patient Interviewing

After you have obtained the basic identifying information about the patient (name, age, address), you may conduct a limited interview, even in the field. The situation will dictate the scope of the interview. If possible, collect only information critical to field management. The interview should be open-ended—patients should not be directed, but rather allowed to tell their stories in their own ways.

To make the interview easier:

- Begin with an open-ended question (What problems have you been having?).
- Give patients the floor. Do not be afraid of silences, even those that seem intolerably long. Stay attentive and relaxed. Particularly, remain silent when patients who are overwhelmed by emotion stop speaking. Avoid the temptation to soothe the patients and to prevent crying and other expressions of emotion. Expressing emotion is often therapeutic; usually patients express themselves more easily after their intense emotions are released. Silence allows the patients to gain control of themselves.
- Communicate with the patients by using noncommittal words or phrases—"Go on" or "I see"—or by using gestures—a nod of the head, for instance. This technique, called facilitation, can be used to return patients to topics for which more information is needed. For example, a patient may have referred briefly to suicidal thoughts

and then moved on to another subject. When he or she finishes with the new subject, you might say, "You say you have thought of suicide?" This suggests to the patient that you are interested in what the patient has said and would like to learn more.

- Point out to the patients something of interest in their conversation or behavior of which they may not be aware. This technique, known as confrontation, is a description of the patient, based not on judgments but on the interviewer's observations. You might remark, "You seem worried," or "You sound very angry." Such comments often lead to freer expressions. They must, however, be neither critical nor condescending.
- Ask questions if necessary to keep the interview moving—but make them as nondirective as possible. Avoid questions that can be answered with a simple yes or no. "How" and "what" questions are better.
- Throughout the interview, provide support and reassurance with actions that demonstrate interest in the patient. Reassurances should never be unrealistic or foster unreasonable expectations (e.g., "You have nothing at all to worry about"). Instead, identify the patient's strengths and reinforce them ("Despite all the troubles you have had, you seem to have done a very good job at work").

Some patients find it difficult to deal with the lack of structure in nondirective questioning. This is particularly true of adolescents, severely depressed patients, and confused or disorganized patients. In such cases, when open-ended questions are met with uncomprehending silence, a more structured interview may produce better results.

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## MODULE XIV.

# Extrication and Rescue Techniques

**NOTE:** Module XIV is not presented in the same format as the other fourteen (14) modules because it is assumed that at the paramedic training level the trainee will have already received training in extrication and rescue procedures and techniques as a requirement for EMT or EMT-A certification. To provide the instrument for this training, the Department of Transportation in 1979 published the training curriculum *Crash Victim Extrication Training Course.**

For the purpose of this Module, the following general information is provided:

An Emergency Medical Technician (EMT) is an individual who is trained to assess and manage patients who are acutely ill or seriously injured. His or her emphasis is patient care, but the role of EMT also requires basic skills that are not necessarily medical. More specifically, the EMT must be trained in basic rescue procedures. The emphasis of an EMT's rescue training should be on those areas that are directly related to patient care, that is, recognition and management of hazardous environments, gaining access to the patient, correcting the immediate life-threatening condition, disentangling the patient, preparation for removal, removal and continued care in transport to the appropriate medical facility.

When the level of rescue training required by each EMT is determined, certain factors must be considered. First, the locale has a great deal to do with the type of training required. For example, the EMT's who function in an area with many lakes, rivers, or streams should be trained in basic skills of water rescue. Those EMT's active in a mountainous area would be more appropriately trained in skills such as rappelling. (Those EMT's who will work in the plains of Iowa need not be trained in mountain rescue.)

Second, the role of an EMT must be determined with respect to the entire emergency-response system. If an EMT is responding to the scene and is accompanied by a fully trained rescue team and a fully equipped vehicle, it is not necessary for the EMT to have more than a general understanding of the capabilities of the rescue team. If, however, an EMT is functioning in a rural area and is called upon to assume the role of rescue personnel as well as an emergency medical technician, then more extensive training is needed. The extent of training necessary can only be determined at a local level, but it is suggested that an EMT be able to:

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*Contains set of 54 color slides, Instructor's Manual, and Student Manual. Available from National Audio Visual Center, GSA, Washington, D.C. 20409. Additional Instructor's Manuals and Student Manuals available from Government Printing Office.

A. Recognize and manage situations that pose a threat to the patient, the EMT, or bystanders. This would include such hazardous conditions as:

1. Traffic at the scene of an accident.
2. Downed electrical wires.
3. Fire.
4. Explosive materials.
5. Dangerous (toxic) materials.
6. Radioactive materials.
7. Unstable vehicle or structure (e.g., an automobile on a ledge).

B. Demonstrate techniques for gaining access to the patient. In most instances, such techniques would apply to rescuing patients trapped in a wrecked automobile, but an EMT should also understand the techniques for gaining access to a patient separated by:

1. Adverse terrain.
2. Water.
3. Mountains.
4. Ravines.
5. Structural damage (e.g., collapsed wall).

**Note:** An EMT need not be able to perform all skills, but should be able to summon the appropriate resources and assist when necessary.

C. Demonstrate the proper procedures for disentangling the patient. Again, as with gaining access to the patient, this procedure would apply to dealing with vehicular accidents, but the EMT must be able to disentangle the patient from any type of confining environment, being sure to avoid further aggravation of existing injuries.

D. Demonstrate various patient carries and lifts that can be used in emergency and nonemergency situations. These carries and lifts should include:

1. Fireman's carry.
2. Fireman's drag.
3. Pack-strap carry.
4. Extremities carry.
5. Seat carry.
6. Traction blanket lift.
7. Two-person lift.

**Note:** All carries and lifts mentioned are presented as a segment of the EMT ambulance training program.

E. Demonstrate how the patient at the completion of all emergency care and immobilization procedures is prepared for transport. The devices used for transporting the patient should include:

1. Orthopedic scoop-type stretcher.
2. Portable stretcher.
3. Chair stretcher.
4. Stokes basket.

**Note:** Transfer techniques should include transport over rough terrain, ravines, etc.

Local resources and training materials should be consulted when planning and implementing your training program. The following references are suggested:

American National Red Cross. *Lifesaving—Rescue and Water Safety.* Washington, D.C.: American National Red Cross, 1974.

Bahme, Charles W. *Fire Officer's Guide to Emergency Action.* Boston, Mass.: National Fire Protection Association.

Cornforth, James. *National Lifeguard Manual.* YMCA, 1974.

Civil Defense Preparedness Agency. *Rescue Skills and Techniques.* Baltimore, Md.: S.M. 14.2, 1972.

Department of Transportation, National Highway Traffic Safety Administration. *EMT Crash Victim Extrication Course.* Washington, D.C.: U.S. Government Printing Office, July 1973.

Erven, Lawrence W. *First Aid and Emergency Rescue.* Beverly Hills, Calif.: Glencoe Press, 1970.

*Extrication and Casualty Handling Techniques.* Farnham Folsom, Philadelphia, Pa.: J. B. Lippincott Co., 1975.

Grant, Harvey. *Vehicle Rescue.* Bowie, Md.: Robert J. Brady Co., 1975.

Headquarters, Department of the Army. *Transportation of the Sick and Wounded.* Washington, D.C.: U.S. Government Printing Office, 1970.

Meidl, James H. *Hazardous Materials Handbook.* Beverly Hills, Calif.: Glencoe Press, 1972.

National Fire Protection Association. *Fire Protection Guide on Hazardous Materials.* Boston, Mass.: National Fire Protection Association, 1973.

National Ski Patrol System, Inc. *Technical Manual of Lift Evacuation.* Denver, Colo.: National Ski Patrol System, Inc., No. 505.

Nethercutt, Dawson. *The International Manual of Basic Rescue Methods.* International Rescue and First Aid Association, 1975.

Ohio Trade and Industrial Education Service. *Emergency Victim Care, a Textbook for Emergency Medical Personnel.* 1st ed. Columbus, Ohio: Ohio Trade and Industrial Education Service, 1971.

## Module XV.

# Telemetry and Communications

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# Module XV.

# Telemetry and Communications

## Unit 1. Emergency Medical Services Communication System

An emergency medical services (EMS) communication system helps coordinate all groups and persons involved in emergency response and care. Such a communication system coordinates emergency medical services and resources during major emergencies and disasters, as well as during individual emergencies.

### Phases of an Emergency Medical Services Communication System

#### ACCESS AND NOTIFICATION

How to contact the system in an emergency is of primary importance to EMS communications. The usefulness of the telephone, the method of access most available to the public, is limited by number and location. Often the public does not know whom to call for emergency assistance; the Yellow Pages offer a confusing array of emergency ambulance services and operators may be unprepared to accept and refer a true emergency call.

The telephone is most useful in an emergency when the 911 emergency telephone number services is available. A bystander then can dial 911 from a home telephone or from any public pay telephone (without the use of a coin) to notify the *P*ublic *S*afety *A*nswering *P*oint (PSAP). The PSAP either shares a location or has direct communications links with the communications control center (CCC) for the appropriate local police, fire, and medical emergency services. The operator who first answers a 911 call can immediately notify or put the caller in communication with the appropriate emergency service.

Some communities also have radio-telephone callboxes available on the highways for emergency use. When properly connected for prompt access to an emergency service center, the highway callboxes make it easier for citizens to obtain the needed emergency help.

The notification phase of emergency medical communications can be improved through public education. The public should know when emergency care is needed, whom to call for appropriate aid, what to say in order to obtain advice, and what to expect in the way of a response.

#### DISPATCH

Once the system has been notified, there must be a process that selects the appropriate emergency vehicles and directs them to the scene of the illness or injury. Vehicles can be dispatched by telephone (hard-line communication), radio, or a combination telephone/radio connection (phone patch).

It is easier and more economical to coordinate emergency services if the CCC dispatches police, fire, and emergency medical vehicles. Such centers can be organized to cover county or other regional areas, depending on local policy and municipal preferences. The CCC is especially helpful in coordinating emergency services during major emergencies and disasters.

### Communication between dispatcher and emergency personnel

The Emergency Medical Technician-Paramedic (EMT-P) must have use of a radio at all times: En route to the emergency, at the scene, during transport to the hospital, and while returning to base after completing a call. The dispatcher must at all times be able to put the paramedic in radio contact with medical advice.

Dispatcher-to-paramedic communication is important for several reasons. It enables the dispatcher to give the EMT-P additional information while en route. It lets the dispatcher know where the emergency vehicle is and about how long it will be busy. It also allows redirection of the vehicle either when en route to the original destination or when returning to the base. Further, it allows the EMT-P to request police or fire department assistance, additional ambulances, or additional emergency medical personnel.

### Three-way communication among the paramedic, physician, and emergency department

Physicians, although usually hospital-based, may be linked to the ambulance by a communication system in their cars, homes, or offices so that they can order advanced life-support procedures at the scene and during transport. In some States, specially-trained nurses, operating under standing orders from physicians, can provide this consultation link with EMT-P's.

Communication with emergency department personnel allows you to report the patient's condition and expected arrival time. This procedure gives the emergency department time to assemble necessary equipment and prepare for specific problems. In addition, such communication allows redirection of the EMS team to another facility if the original one does not have adequate treatment capabilities or bed space for a particular case.

Paramedics often use two-way radios to communicate with the physician, nurse, and emergency department. Communication patching at the base station allows the ambulance en route to communicate by mobile radio via phone patch or cross-frequency radio patch to someone at the accident scene. In addition, the ambulance en route or at the scene can communicate by mobile radio via patch to a physician at home or in a vehicle equipped with a telephone or citizens band (CB) radio.

Portable radio transmitter/receivers can be used for communications between the emergency scene and the hospital physician, usually via the ambulance relay. In this way, you can receive instructions at the scene without having to return to the vehicle to use the mobile transmitter/receiver.

### Communication among area hospitals

When dealing with mass casualties, communication among area hospitals may be necessary to request blood or special supplies. Radio, telephone, or a radio-telephone combination may be implemented.

### Communication links with support agencies

Communication with such support agencies as the fire and police departments, the civil defense office, or crisis intervention teams can be accomplished through CCC's or through separate dispatch centers.

Although it is possible for dispatch centers to communicate by telephone, such connections may be disrupted or overloaded during a disaster. Therefore, dedicated telephone lines (lines used exclusively between two points) or a backup radio network should be available.

### Coordination of other radio networks to be used in contingency planning

Private communication systems that are normally available during disasters include:

- The Amateur Radio Public Service Corps (ARPSC). (For information on specific area groups, contact the ARPSC at the American Radio Relay League, Inc., Newington, Connecticut 06111.)
- The Radio Amateur Civil Emergency Service (RACES). (Contact local civil defense officials for information on community resources.)
- Business and municipal radio service systems (e.g., taxi dispatching and trucking services).
- CB highway safety groups, such as REACT and NEAR. (Some have been specially organized to respond to emergency situations through Channel 9, a designated emergency channel.)

## System Components

The hardware (components) used for medical communications varies considerably from system to system. Some of the common hardware of a communication network includes:

### BASE STATION TRANSMITTERS AND RECEIVERS

The base station is used for dispatch and coordination and, ideally, should be in contact with all other elements of the system. Directional antennas should be placed in the proper positions to serve the desired area for radio coverage and at the same time not interfere with bordering service areas. The highest point is not necessarily the best location. Wire connections from base radio units to the dispatch center may be the most desirable method for reducing the number of airwave (radio) transmissions. This method allows greater use of radio channels and does not interfere with neighboring services. Transmission levels are limited by the Federal Communications Commission (FCC). The minimum usable levels for signal reception are limited by manmade noise, such as automobile sounds. A good antenna system can partially compensate for these limitations.

Base stations with multiple channels to provide automatic rotation to an open channel are available.

### MOBILE TRANSMITTER/RECEIVERS

Mobile transmitter/receivers are mounted in the emergency vehicles. They come in different power ranges. The antenna system, the power range of the transmitter/receiver, and the kinds of buildings and terrain in the area determine the distance over which the units can transmit a signal. The reliability and range of radio transmission can by and large be insured if the network of base stations and telephone interconnections is properly engineered.

### PORTABLE TRANSMITTER/RECEIVERS (TWO-WAY PORTABLE RADIOS)

Portable transmitter receivers are handheld so that you can carry them outside the emergency vehicle. Medical control physicians also carry portable transmitter/receivers to use when they cannot be reached immediately via the hospital-circuit radio.

Portable units usually have a power limitation of 5 watts. The signal of a handheld transmitter can be boosted to equal the range of a mobile unit by retransmission through the vehicle or base station. Portable transmitter/receivers can transmit and receive multiple frequencies.

### REPEATERS

Repeaters are miniature base stations used to extend the transmitting and receiving range of telemetry or a voice-communications system. Repeaters receive a signal on one frequency and retransmit it on a second frequency.

Repeaters are either fixed or mobile (carried in the emergency vehicle), and many systems employ both. They are useful for extending the transmission range in hilly and mountainous areas, as well as for extending the range of portable transmitter/receivers. In both cases, the primary hardware (the patient-side radio) transmits the signal via the repeater in the vehicle; the signal then is retransmitted to the base station.

### REMOTE CONSOLE

The remote console is a control console connected to the base station by telephone lines. It allows use of the base station from another location such as a hospital emergency department.

The remote console both receives voice and telemetry signals from the field and transmits verbal messages back through the base station equipment. Remote consoles usually contain an amplifier and a speaker for incoming voice reception, a decoder for translating telemetry signals into an oscilloscope trace or readout, and a microphone for voice transmission.

### ENCODERS AND DECODERS

The dispatch center, ambulances, and hospitals in a communications system all share a small number of radio frequencies. All radio receivers on the same channel would be activated by every transmitted message if the signals were not directed to the desired recipient by the sender. The encoder and decoder direct the incoming messages to the desired recipient.

The encoder resembles a telephone dial. When a number is dialed, the encoder transmits a pulsed tone—the number of pulses equals the number dialed. All receivers operating on that frequency receive the pulsed tone. Each individual receiver, however, responds to only its own three- or four-number address code. When this pulsed code reaches the receiver, the decoder opens the receiver's audio circuit. The encoder-decoder system does not prevent other users from listening in, but it does keep them from receiving unwanted messages.

### TELEPHONE

In addition to radio communications, many systems employ hard-line (telephone) backup to link fixed components of the system, such as hospitals and fire and police services. Telephones can also be patched into radio transmission through the base station or through manual control at the CCC. This can allow communication between paramedics using radios in the field and physicians using their telephones at home. Although some telephone lines are already provided with amplifiers to ensure a strong, undistorted signal, line clearing may be required at individual locations.

Figure 15.1 illustrates a sample communications system.

## Radio Communications: Voice and Telemetry

### RADIO FREQUENCIES

Radio frequencies are designated in cycles per second. One cycle per second is defined as a hertz. The following abbreviations commonly are used:

hertz (Hz) = cycle per second.
kilohertz (kHz) = 1,000 cycles per second.
megahertz (MHz) = 1,000,000 cycles per second.
gigahertz (GHz) = 1,000,000,000 cycles per second.

Radio waves are part of the electromagnetic frequency spectrum, which is assigned for different purposes. Different frequency bands have different properties. In general, the higher frequency bands have a shorter transmission range but also less signal distortion (interference and noise).

Emergency medical communications use both the very-high-frequency (VHF) band and the ultrahigh-frequency (UHF) band. The VHF band extends from about 30 to 175 MHz and is divided into a low band (30 to 50 MHz) and a high band (150 to 175 MHz). The low-band frequencies have ranges of up to 2,000 miles. These ranges are unpredictable, however, because changes in atmospheric conditions sometimes produce "skip interference," which results in patchy losses in communication. The high-band frequencies are almost free of skip interference, but have a shorter range. Specific frequencies in the VHF high band have been allocated by the FCC for emergency medical purposes.

The UHF band extends from 300 to 3,000 MHz. Most medical communications are in the 450- to 470-MHz range, which is free of skip interference and has little noise (signal distortion). The UHF band has better building penetration than the VHF band, but has a shorter range. UHF waves are more likely to be absorbed by objects in the environment, like trees and bushes.

Both VHF and UHF communication use frequency-modulated (FM) equipment rather than amplitude-modulated (AM) equipment. (Citizens band radios, in contrast, are AM.) There is less noise and interference with FM than with AM equipment.

The FCC, which assigns frequencies, has set aside some frequencies on both bands for emergency communications. A special set of 10 channels (paired frequences) for EMS communication allows substantial channel space and great flexibility of use for voice and telemetry.

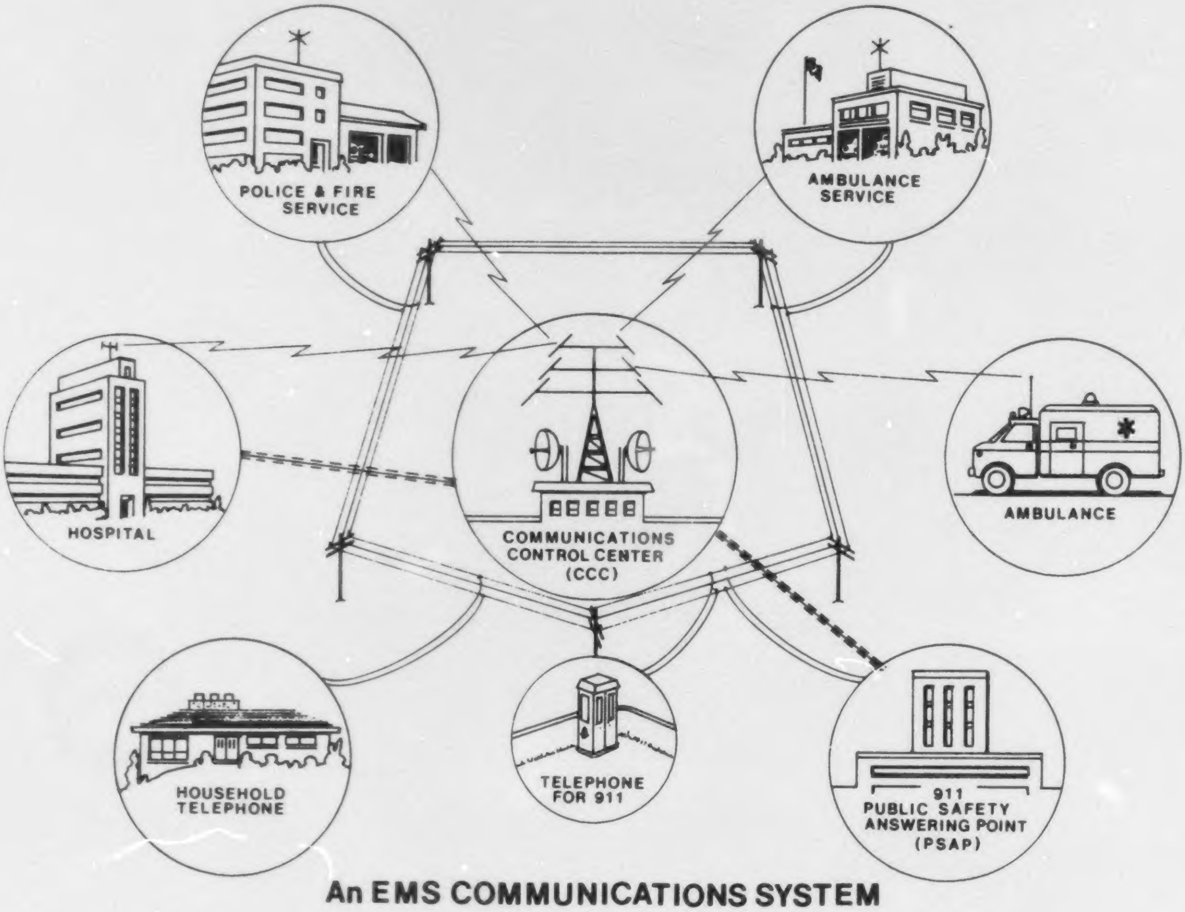
POLICE & FIRE SERVICE
AMBULANCE SERVICE
HOSPITAL
COMMUNICATIONS CONTROL CENTER (CCC)
AMBULANCE
HOUSEHOLD TELEPHONE
TELEPHONE FOR 911
911 PUBLIC SAFETY ANSWERING POINT (PSAP)
An EMS COMMUNICATIONS SYSTEM

**Figure 1. Sample Communications System**

### BIOTELEMETRY

The term "biotelemetry" refers to a technique for measuring vital signs and transmitting them to a distant terminal. When the term "telemetry" is used in emergency medicine, it usually refers to transmission of an electrocardiogram (EKG) signal from the patient to a distant receiving station. In the EMS system, EKG telemetry shares a circuit with, or is multiplexed on, a normal voice channel using a subcarrier of 1,400 Hz. The hospital must be able to communicate with the paramedic while biotelemetry is in progress. Multiplexing may result in minor degradation of the voice transmission over the same channel.

The EKG signal consists of low frequencies (100 Hz and less). Radio signals, especially FM signals, are not easily modulated below 300 Hz. To avoid distortion, the EKG signals are coded into a higher frequency, using a reference audio tone of 1,400 Hz. The 1,400-Hz tone is then modulated by the EKG signal for radio transmission. When the transmission reaches the distant terminals, it is amplified and demodulated to produce a signal voltage identical to the original EKG signal.

Distortion of the EKG signal by extra spikes and waves is called "noise." Noise can be caused by:

- Loose EKG electrodes.
- The patient's muscle tremors.
- Sources of 60-cycle alternating current, such as transformers, power lines, and electrical equipment.
- The weakening of transmitter power due to either weak batteries or transmission beyond the base-station range.

### USE OF FREQUENCES IN A SYSTEM

Assigned frequencies are used in different systems. In a simplex system, portable units can transmit in only one mode (voice or telemetry) or receive only voice at any one time; such systems require only a single radio frequency. When a network uses two frequencies simultaneously, it is known as a duplex. Another alternative is to multiplex two or more signals so that they can be transmitted on one frequency at the same time.

# Unit 2. Communications Regulations and Procedures

## Federal Communications Commission

The FCC is a national regulatory and controlling agency that licenses individuals and communications systems and assigns frequencies. In addition, the FCC establishes and enforces communications regulations. To enforce its regulations, the FCC monitors frequencies and performs road checks. It also spot-checks base stations and their records.

The FCC has field offices throughout the country. All communication plans must be coordinated with these field offices.

The EMT-P should be familiar with FCC regulations.

## Protocols and Communication Procedures

Standard operating procedures (SOP's) are necessary to ensure appropriate and efficient use of the medical communications system. Standard procedures eliminate unnecessary communication that could overload communication channels. By providing a structure for essential communications, SOP's make it possible for the physician to quickly receive information about a patient's condition and rapidly transmit orders for the patient's care.

The possibility of having a message misunderstood is reduced with SOP's. When these procedures involve coded messages, all persons using the communication system—paramedics, dispatchers, physicians, emergency department staff, and others directly involved—must understand the code and use it properly.

## Dispatch Procedures

The dispatcher gathers information about the emergency, directs the appropriate vehicle to the scene, and gives the caller advice on how to manage the emergency until help arrives. In addition, the dispatcher monitors and coordinates field communications. While performing these duties, the dispatcher must follow FCC guidelines.

### INFORMATION GATHERING

The dispatcher usually collects information by asking a short series of questions. When a call for an ambulance is received, the dispatcher records the necessary information as rapidly as possible. If tape-recording equipment is available, a tape should be made of each call to serve as a backup record.

The dispatcher should obtain the following information:

- The phone number of the caller. This allows the dispatcher to contact the caller for more information (e.g., if the rescue team is unable to find the address and needs better directions). Asking for caller's phone number also reduces nuisance calls—prank callers are reluctant to give their phone numbers. In addition, the phone number can help the dispatcher determine the caller's location if the caller (e.g., a traveler calling from the highway) is unfamiliar with the area.
- The patient's name (if known). This information will help the rescue team to identify the patient.

- The patient's exact location, including street name and number. The dispatcher must obtain the proper geographic designation (e.g., whether the street is East Maple or West Maple) and the community name, since nearby towns may have streets with the same names. If the call comes from a rural area, the dispatcher should establish landmarks, such as the nearest crossroad or business, or a water tower, antenna, or other easily identifiable landmark that will help the rescue team locate the emergency.
- The nature of the patient's problem.
- Specific information about the patient's condition. (Is the patient conscious, breathing, bleeding badly, or in severe pain?)
- Whether the emergency is a highway accident. If it is, the dispatcher should obtain the following additional information:
  - —Kinds of vehicles involved (cars, trucks, motorcycles, buses). If trucks are involved, the dispatcher should ask what they are carrying to determine the possibility of explosion, fire, or noxious fumes.
  - —The number of persons involved and the extent of injuries. Even if the caller can only guess at this information, it can give the dispatcher an idea of the size of the problem.
  - —Known hazards, including traffic dangers, downed electrical wires, fire, submerged vehicles, etc. Knowing about these hazards allows the dispatcher to contact whatever other agencies will be needed (e.g., the utility department to deal with downed wires).

A printed form can help the dispatcher obtain all the necessary information and provide a record of the call

### DISPATCH

After receiving the necessary information, the dispatcher should ask the caller to remain on the line. The dispatcher then must make several decisions.

- What is the nature of the problem? Is it life-threatening?
- Are paramedics needed?
- Are support services—police, fire, heavy rescue—needed?
- Which crew(s) and vehicle(s) should respond? This decision depends on the nature and the location of the emergency and on the availability of the units. Thus, the dispatcher must know the status of every area vehicle and crew.

In order to make these decisions about medical emergencies, the dispatcher needs training in emergency medical care. The Division of Emergency Medical Services (recently disbanded) of the U.S. Department of Health and Human Services and the Emergency Medical Services Branch of the National Highway Traffic Safety Administration recommend that EMS dispatchers receive the same EMT training as the medical crews that they dispatch. In 1976, the Department of Transportation developed a special curriculum for dispatchers for the first time. This training curriculum, however, is not always useful, because most dispatchers on the payrolls of fire departments and law enforcement agencies are professionals, many of whom have significant seniority and accrued benefits—making their replacement with EMT's or nurses not economical or occupationally feasible. In order to upgrade the emergency medical expertise of the dispatcher, the Department of Transportation supported the development of the *Emergency Medical Dispatch Priority Card System* by Dr. Jeff Clawson and Robert Peters. This training instrument should be available for purchase from the Government Printing Office by late fall, 1981.

### RECORDS

Either the EMT-P or the dispatcher or both should record the key times for each emergency, including when the call was received, when the vehicle began its run, when the crew arrived at the emergency and when it left, when the patient reached the hospital, and when the vehicle and crew were back in service.

## Relaying Information to the Physician

Radio communications between the paramedics and their physician directors should be brief and accurate. To ensure that information is transmitted consistently, so that nothing significant is omitted, follow a standard procedure. Be sure the information includes:

- The patient's age and sex.
- Vital signs.
- Chief complaint.
- A brief history of the present illness.
- Physical findings, including:
  - —State of consciousness.
  - —General appearance.
  - —Other pertinent observations.

What follows is an example of a concise, informative transmission for a patient in congestive heart failure: We have a 53-year-old man with a pulse of 130 and regular, blood pressure 190/120, and respirations 36 per minute. He is complaining of severe shortness of breath that wakened him from sleep and is worse when he is lying down. He has a history of high blood pressure and takes Diuril at home. He is alert, but in considerable distress. He has rales and wheezes in both lung fields. We are sending you an EKG.

The above transmission takes less than 30 seconds but efficiently provides the physician with the information needed to rapidly diagnose the problem and order appropriate treatment.

In contrast, consider the following:

**EMT–P:** We have a patient with a pulse of 130, blood pressure of 190/120, and respirations of 30. We are sending you a strip.

**Doctor:** Fine, but what's his problem?

**EMT–P:** He's short of breath.

**Doctor:** How long has this been going on?

**EMT–P:** Just a minute. (Pause) He says it woke him up from sleep about an hour ago.

**Doctor:** Does he have any underlying medical problems?

**EMT–P:** He takes medicine for hypertension.

**Doctor:** Is he in any distress?

**EMT–P:** Yes, he's having a hard time breathing.

**Doctor:** What do his lungs sound like?

**EMT–P:** Just a minute. (Pause) He has rales and wheezes all over.

This type of communication is obviously far less efficient. It wastes time and annoys and frustrates everyone. Information should be gathered at the scene and organized clearly in the EMT–P's mind before the physician is contacted. The reporting procedure can be written on a card and posted in the vehicle or on the transmitter, where the paramedic can refer to it when reporting in.

## Techniques

Because radio communications equipment varies from manufacturer to manufacturer, the directions in this section are general, rather than specific. The directions must be supplemented with more specific instructions for the equipment in use.

### HOW TO USE A MOBILE TRANSMITTER/RECEIVER:

- Turn unit on
- Adjust squelch.
- Listen before transmitting to be sure airways are free of other communications.
- Hold microphone far enough from your mouth to avoid air noise made by exhaling.
- Push the push-to-talk button, and pause before speaking.
- When calling another unit, use its call letters first, and yours second.
- Follow these guidelines when using the radio:
  - —Use an understandable rate of speed.
  - —Do not talk too loudly.
  - —Do not hesitate.
  - —Articulate clearly.
  - —Speak with good voice quality.
  - —Avoid dialect or slang.
  - —Do not show emotion.
  - —Avoid vocalized pauses (such as "um," "uh," or "hmm").
  - —Use proper English.
  - —Avoid excessive transmission.
- Use the call sign to let others know that the transmission has been completed.

### HOW TO USE A PORTABLE TRANSMITTER/RECEIVER:

The use of a portable transmitter/receiver is similar to the use of a mobile transmitter/receiver. But since the antenna on the portable unit is not fixed in place, it must be kept vertical while in use, so that the signal can be properly transmitted to the vehicle. From the vehicle, the signal can be transmitted to the base station.

### HOW TO USE A DIGITAL ENCODER:

- Turn unit on.
- Adjust squelch.
- Listen before transmitting to be sure that the airways are free of other communication.
- Select the address code to be dialed.
- Dial the address code.
- Hold the microphone far enough from your mouth to avoid air noise made by exhaling.
- Push the push-to-talk button and pause before speaking.
- Call the dialed unit.
- Use the call sign to let others know that the transmission has been completed.

### HOW TO TRANSMIT PATIENT ASSESSMENTS AND TELEMETRY:

- Turn the unit on.
- Adjust squelch.
- Listen before transmitting to be sure the airways are free of other communication.
- Hold the microphone far enough from your mouth to avoid air noise made by exhaling.
- Push the push-to-talk button and pause before speaking.
- Call the physician, either directly or through a relay.
- Connect or attach the electrodes to the telemetry transmitter.
- Follow local procedures for relaying patient assessment.
- Activate telemetry transmitter for the minimum time required by the receiving physician (approximately 15 seconds).
- Verify the physicians reception of the information and the quality of the transmission.

## Glossary

**dispatch:** To transmit calls to emergency medical services and to direct emergency vehicles, equipment, and personnel to the scene of a medical emergency.

**duplex:** A radio communications system employing more than one frequency.

**Federal Communications Commission (FCC):** The Federal regulatory agency that licenses individuals and communications systems and assigns radio frequencies.

**frequency:** The number of periodic waves per unit of time; radio waves are expressed in cycles per second.

**frequency modulation:** A method of converting an analog signal, such as an electrocardiogram, into a tone of varying pitch that can be transmitted over the radio.

**gigahertz (GHz):** A unit of frequency measurement equaling 1 billion Hz; indicates frequencies of 1 billion cycles per second.

**hertz (Hz):** A unit of frequency measurement; 1 Hz equals 1 cycle per second.

**kilohertz (kHz):** A unit equaling 1,000 Hz; it indicates frequencies of 1,000 cycles per second.

**megahertz (MHz):** A unit equalling 1 million Hz; indicates frequencies of 1 million cycles per second.

**multiplex:** In a radio communications system, a method by which simultaneous transmission and reception of voice and electrocardiogram signals can be achieved over a single frequency.

**noise:** Extra spikes, waves, and complexes in the EKG signal caused by various conditions such as muscle tremor, 60-cycle alternating-current interference, improperly attached electrodes, and out-of-range transmission.

**patch:** Connection of telephone line and radio communication systems making it possible for police, fire department, and medical personnel to communicate directly with each other by dialing into a special phone.

**repeater:** A miniature transmitter that picks up a radio signal and rebroadcasts it, thus extending the range of a radio communications system.

**response time:** The length of time required for the emergency medical services team to arrive at the scene of an emergency after receiving a call for help.

**simplex:** A communications system that can transmit only in one mode at a time, or receive voice transmissions only.

**telemetry:** The use of telecommunications for automatically indicating a recorded measurement at a location different from the measuring instrument, such as an electrocardiogram sent from an ambulance and received at a hospital.

**UHF band:** The ultra-high-frequency band; refers to the portion of the radio frequency spectrum between 300 and 3,000 MHz.

**VHF band:** The very-high-frequency band; refers to the portion of the radio frequency spectrum between 30 and 150 MHz.

## Reference

U.S. Department of Health, Education, and Welfare. *Emergency Medical Service Communication Systems.* Washington, D.C.: U.S. Government Printing Office, August 1972.

# Appendix A - Glossary

**a-, an-, ano-:** Prefix meaning without.

**aa:** Abbreviation in prescription notation; means *ana,* of each.

**abandonment:** A termination of a paramedic-patient relationship by the paramedic without consent of the patient and without care to the patient by qualified medical providers.

**ABC's:** *A*irway, *B*reathing and *C*irculation; the first three steps in the examination of any victim; basic life support.

**abdomen:** The large body cavity below the diaphragm and above the pelvis.

**abdominal:** Pertaining to the abdomen.

**abduct:** To draw away from the midline.

**abduction:** The act of abducting; the state of being abducted.

**abnormal:** Not normal; malformed.

**abortion:** The premature expulsion of the products of conception from the uterus; miscarriage.

- **incomplete abortion:** The expulsion of part of the fetus, or of other parts of the products of conception, from the uterus before term.
- **missed abortion:** Retention of the contents of the uterus after the fetus dies.
- **spontaneous abortion:** An abortion occurring naturally.
- **therapeutic abortion:** An induced abortion, usually accomplished by qualified medical personnel under ideal conditions; the purpose is usually to preserve the life of the mother.
- **threatened abortion:** The appearance of signs and symptoms of possible loss of the fetus; characterized by bleeding and cramps.

**abrade:** To wear away by mechanical action; to scrape away a substance.

**abrasion:** An injury consisting of the loss of a partial thickness of skin from rubbing or scraping on a hard, rough surface; also called a brush burn, friction burn.

**abruptio placentae:** A premature separation of a normally implanted placenta from the uterine wall usually occurring during the third trimester of pregnancy and accompanied by pain and bleeding.

**abscess:** A localized collection of pus in any part of the body; formed by disintegration of tissues and accumulation of white blood cells.

**absolute refractory period:** The period during the cardiac muscle fiber depolarization process when no stimulus can cause the fiber to depolarize again; occurs during the QRS interval to the beginning of the T wave.

**absorbent:** Having the quality to attract another substance and incorporate it into its structure.

**absorption:** The act of absorbing; the passage of one material into another's internal structure.

**ac:** Abbreviation for *ante cibum,* meaning before eating.

**accelerated nodal rhythm:** The name given for a heart rhythm that is stimulated by the AV node, but is faster than the nodal intrinsic rate of 40 to 60 beats per minute.

**access:** A way or means of approach; the action of going [illegible] or reaching.

**acetabulum:** The cup-shaped cavity on the external surface of the innominate bone in which the rounded head of the femur fits.

**acetic acid:** The principal acid in vinegar.

**acetone:** A chemical compound found normally in small amounts in the urine; diabetic patients are said to produce a "fruity odor" when larger amounts are produced in blood and urine.

**acetylcholine:** A reversible acetic acid ester of choline; found in the synapses of the autonomic system, especially at the end plates of the parasympathetic system; parasympathomimetic agent; medication for patients with myasthenia gravis.

**acid:** Sour; a substance that forms hydrogen ions in solution and from which hydrogen may be displaced by a metal when a salt is formed.

**acidosis:** An abnormal state of the body in which the pH falls below 7.35; excessive amounts of carbon dioxide (respiratory acidosis) and lactic and organic acids (metabolic acidosis) produce the acidotic state.

**acromioclavicular joint:** The point of the shoulder; the junction (union) between clavicle and scapula plus the supporting ligaments.

**acromion:** The lateral, triangular, bony projection of the scapular spine forming the point of the shoulder with the lateral part of the clavicle.

**activated charcoal:** Powdered charcoal that has been treated to increase its powers of absorption; used in a slurry to absorb ingested poison.

**acute:** Having rapid onset, severe symptoms, and a relatively short duration.

**acute abdomen:** A serious intra-abdominal condition causing irritation or inflammation of the peritoneum, attended by pain, tenderness, and muscular rigidity (board-like abdomen).

**acute myocardial infarction:** The acute phase of a heart attack, wherein a spasm or blockage of a coronary artery produces a spectrum of signs and symptoms, commonly including chest pain, nausea, diaphoresis, anxiety, pallor, lassitude.

**Adam's apple:** The projection on the anterior surface of the neck, formed by the thyroid cartilage of the larynx.

**addiction:** The state of being strongly dependent upon some agent; drugs, tobacco, for example.

**adduct:** To move toward the center of the body, particularly a limb or head.

**adduction:** The act of adducting; the movement of a part toward the midline of the body.

**adipose:** Fatty tissue.

**adjunct:** An accessory or auxiliary agent or measure; an oropharyngeal airway is an airway management adjunct.

**ad lib:** Abbreviation for *ad libitum*, meaning as desired.

**adrenal:** Refers to the adrenal gland or its secretions.

**adrenal gland:** The small gland on the superior aspect of the kidney; produces corticosteroids, catecholamines, and other hormones.

**adrenalin:** The proprietary name for epinephrine.

**adrenergic:** Activated by, characteristic of, or secreting epinephrine or other substances with similar activities (catecholaminic).

**advanced life support:** Basic life support plus invasive techniques leading to definitive therapy to save the patient's life.

**aerobe:** An organism that lives and grows in the presence of free oxygen.

**afebrile:** Without fever.

**afferent:** Bearing or conducting inward.

**affinity:** Attraction.

**afterbirth:** The placenta and membranes expelled after the birth of a child.

**agglutination:** Clumping together of blood cells.

**agonal:** Pertaining to death or dying.

**agonist:** A prime mover; a muscle opposed in action by another muscle, called the antagonist.

**air:** The gaseous mixture which composes the Earth's atmosphere; composed of approximately 21 percent oxygen, 79 percent nitrogen, plus trace gases.

**air chisel:** A chisel attachment for devices powered by compressed air; used to cut away metal and other materials.

**air cutter gun kit:** An air powered tool for cutting that does not produce heat or sparks.

**air embolism:** The presence of air bubbles in the heart or blood vessels causing an obstruction.

**air hunger:** A term for labored breathing.

**air passage:** Any of several tubes that normally transmit air into the lungs.

**air splint:** A double-walled plastic tube that immobilizes a limb when sufficient air is blown into the space between the walls of the tube, to cause it to become almost rigid.

**airway:** An air passage.

**artificial airway:** A device used to assure free passage of air through the nose, mouth, and pharynx into the trachea.

**lower airway:** The air passage from the larynx to the pulmonary alveoli.

**upper airway:** The air passage from the nose and mouth to the larynx.

**albumin:** A protein substance found in human tissues as well as in other animals and in plants.

**alcohol:** A transparent, colorless, volatile fluid produced by fermentation of carbohydrates with yeast.

**alcoholic:** Pertaining to or containing alcohol; also a person who becomes habituated, dependent, or addicted to alcoholic consumption.

**alimentary tract:** The digestive tube from the mouth to the anus.

**alkali:** Any compound of electropositive element (usually a metal such as sodium) in combination with an electronegative hydroxyl ion or similar ion.

**alkaline:** Having a pH greater than 7.0; in human physiology, having a pH greater than 7.35.

**alkalinizing agent:** A substance used to increase pH or alkalinity; usually used to offset acidosis.

**alkalosis:** An abnormal state of the body in which the pH rises above 7.45; loss of too much carbon dioxide by hyperventilation (respiratory alkalosis) or too much acid by vomiting or by an overdose of alkalizing agents (metabolic alkalosis).

**allergen:** A substance capable of inducing an allergy or specific hypersensitivity.

**allergic reaction:** A local or general reaction to an allergen, usually characterized by hives or tissue swelling or dyspnea.

**allergy:** Hypersensitivity to a substance, causing an abnormal reaction.

**alopecia:** Baldness.

**alpha particle:** A positively charged nuclear particle consisting of two neutrons and two protons; ejected from the nucleus of a radioactive atom.

**alpha receptor:** A center that reacts only to those compounds called alpha adrenergic, or alpha blockers.

**alpha stimulator:** A substance that activates the alpha receptors; also alpha adrenergic.

**alveolar ridge:** The bony remains of the jaws from which teeth have been removed.

**alveolus:** A cavity; specifically, the socket holding a tooth; or a terminal air sac of the lung.

**amaurosis:** Loss of sight without apparent lesion of the eye, or from disease.

**amaurosis fugax:** Sudden transitory partial blindness.

**amenorrhea:** Absence of the menstrual flow.

**AMI:** Abbreviation for acute myocardial infarction.

**amino acid:** An organic acid in which one of the hydrogen atoms has been replaced by a molecular amine group the chief component of protein.

**aminophylline:** A drug of the theophylline family, helpful in the treatment of asthma, chronic obstructive pulmonary disease, and pulmonary edema.

**amnesia:** Loss or impairment of memory.

**amniocentesis:** The aspiration of amniotic fluid from the amniotic sac during the gestation period of the fetus, accomplished by a transabdominal perforation under sterile conditions.

**amniotic fluid:** The fluid surrounding the fetus in the uterus, contained in the amniotic sac.

**amniotic sac:** A thick, transparent sac that holds the fetus suspended in the amniotic fluid.

**amobarbital:** A drug of the barbiturate class, with hypnotic/sedative action; a controlled substance drug.

**amphetamine:** A class of drugs that produces potent central nervous system stimulation; an "upper."

**amplitude:** The height of an EKG wave or complex, measured in millimeters; also, volume of the audio portion of the radio transmission.

**ampule:** A sealed glass container for medication.

**amputation:** Complete removal of an appendage.

**anaerobic:** Life without oxygen.

**anaerobic metabolism:** Metabolism without air, caused by a lack of gas exchange at the cellular level; product of cardiac arrest mechanism, where no oxygen reaches the cells.

**anal canal:** The terminal portion of the alimentary canal extending from the rectum to the anus.

**analgesic:** A pain-relieving drug; a class of drugs used to reduce pain.

**analog signal:** A continuous signal in varying amplitude and direction in proportion to the signal source, EKG for example.

**anaphylaxis:** An exaggerated allergic reaction, usually caused by foreign proteins.

**anasarca:** A severe, generalized edema.

**anastomosis:** A joining together of blood or lymph vessels by an anatomical, natural arrangement or by accessory channels around a joint, whereby if a chief arterial supply is interrupted, a constant blood flow will be achieved; also a surgical joining of two hollow organs, or of part of the same organ, or between blood vessels.

**anatomic position:** The presumed body position when referring to anatomical landmarks; upright, facing the observer, with hands and arms at sides, thumbs pointing away from the body, legs and feet pointing straight ahead.

**anatomical:** Pertaining to anatomy.

**anatomy:** The structure of the body, or the study of body structure.

**anemia:** The condition in which the blood is deficient in hemoglobin, red blood cells, or in total volume.

**anesthesia:** A partial or complete loss of sensation with or without loss of consciousness; can result from drug administration or from injury or disease.

**aneurysm:** A permanent blood-filled dilation of a blood vessel resulting from disease or injury of the blood vessel wall.

**angina pectoris:** A spasmodic pain in the chest, characterized by a sensation of severe constriction or pressure on the anterior chest; associated with insufficient blood supply to the heart; aggravated by exercise or tension and relieved by rest or medication.

**stable angina:** A condition characterized by a recurrent pain in the chest with predictable and similar patterns.

**unstable angina:** A condition characterized by a changing pattern of pain in the chest more easily precipitated, more frequent, greater in intensity, longer in duration, or less responsive to rest or nitrate therapy than the pain previously experienced by the patient; can occur during rest and often precedes an acute myocardial infarction; preinfarctional angina.

**Angiocath:** The Deseret trade name for an intravenous cannula with a Teflon catheter over the metallic needle; has become a generic name for such a device.

**angiogram:** A radiographic depiction of blood vessels through the use of an injected contrast medium.

**angioneurotic edema:** A condition characterized by a sudden appearance of temporary edematous areas of the skin and mucous membranes, often associated with hives, and may be an allergic reaction involving the larynx, face, and other areas of the body; may be a manifestation of anaphylaxis.

**angulation:** The formation of an angle; an abnormal angle in an extremity or organ.

**anion:** An element that in electrolysis passes to the positive pole; an ion that has a negative charge.

**anisocoria:** A condition in which two ocular pupils are not equal in size.

**anomaly:** Any marked deviation from the norm.

**anorexia:** A lack of appetite for food.

**anorexia nervosa:** A serious nervous condition in which the patient loses his appetite and systematically refuses to take adequate nutrition.

**anoxia:** Without oxygen; a reduction of oxygen in body tissues below required physiology levels.

**antagonism:** An opposite or contrary action, such as that between muscles or medications.

**antagonist:** Opponent; commonly used as description of a drug that directly counteracts another drug; naloxone is an opiate antagonist.

**ante-:** A prefix meaning before in time or place.

**antecubital:** In front of the elbow.

**antenatal:** Before birth.

**antepartum:** Before delivery.

**anterior:** Situated in front of, or in the forward part of; in anatomy, used in reference to the ventral or belly surface of the body.

**anti-:** A prefix that shows a negative or reversal of the word root placed after it.

**antiarrhythmic drug:** A class of drugs that prevent or terminate cardiac arrhythmias.

**antibiotic:** A chemical compound produced by and obtained from certain living cells, especially lower plant cells, which is antagonistic to some other form of life, especially pathogenic or noxious organisms.

**antibody:** A substance produced in the body in response to an antigen that destroys or inactivates the antigen.

**anticholinergic:** An agent that blocks passage of impulses through the parasympathetic nerve; parasympatholytic.

**anticoagulant:** A class of drugs that prevents clotting of blood.

**anticonvulsant:** A class of drugs that prevents or terminates convulsions.

**antidote:** A substance to counteract or combat the effect of poison.

**antiemetic:** A remedy used to control nausea and vomiting.

**antigen:** A substance that causes the formation of antibodies.

**antihistamine:** A substance capable of counteracting the pharmacologic effects of histamine by a mechanism other than the production of exactly opposite effects.

**antihypertensive:** A class of drugs that is used to lower blood pressure.

**antipyretic:** A class of drugs that reduces fever.

**antiseptic:** Any preparation that prevents the growth of bacteria.

**antiserum:** A serum that contains antibodies against a specific disease-producing organism, such as rabies antiserum.

**antivenin:** An antiserum containing antibodies against reptile or insect venom.

**anus:** The outlet of the rectum lying in the fold between the buttocks.

**anxiety:** A feeling of apprehension, uncertainty, and fear.

**aorta:** The largest artery in the body, originates at the left ventricle and terminates at the bifurcation of the iliac arteries.

**aortic arch:** The portion of the aorta as it leaves the aortic sinus and begins its posterior descent through the chest.

**aortic sinus:** The small swelling of the aorta just above the aortic valve; point of origin of the coronary arteries.

**aortic valve:** The valve at the outlet of the left ventricle into the aorta; prevents blood return to the heart from the aorta.

**apathy:** Lack of emotion or feeling; indifference.

**apex of the heart:** In normal adults, the pointed end of the ventricle located at the midclavicular line in the fifth intercostal space.

**apex of the lung:** The upper part of the lung, lying above the clavicle.

**APGAR score:** A method developed by Dr. Virginia Apgar for assessing the newborn infant at 1 minute of age by designating a score of 0, 1, or 2 for the following: A = appearance; P = pulse rate; G = grimace; A = activity; and R = respiration. Refer to Module II for further description.

**aphasia:** Loss of power of expression or comprehension of speech, writing, or signs, due to injury or disease.

- **motor aphasia:** An inability to coordinate muscles controlling speech.
- **sensory aphasia:** Inability to understand spoken, written, or tactile speech symbols, due to disease of appropriate centers.

**aphonia:** Loss of voice.

**apical:** Pertaining to an apex.

**apnea:** Absence of respiration.

**aponeurosis:** A flat, fibrous sheet of connective tissue that serves to connect a muscle with the part that it moves.

**apoplexy:** Stroke; cerebrovascular accident, caused by blockage or rupture of an artery.

**apothecary system:** System of weights and measures using pounds and ounces, yards and inches, gallons and pints.

**appendicitis:** Inflammation of the vermiform appendix.

**appendix:** Vermiform appendix, a wormlike diverticulum, or pouch from the cecum.

**aqueous humor:** Fluid circulating in the anterior and posterior chambers of the eye.

**arachnoid:** Resembling a spider's web; the membrane interposed between the dura mater and pia mater; one of the meninges.

**arm:** The upper extremity, specifically that segment between the shoulder and elbow.

**arrest:** Sudden cessation or stoppage.

**arrhythmia:** Any disturbance in the rhythm of the heart.

**arterial blood:** Oxygenated blood.

**arteriole:** A small artery, that at its distal end leads into a capillary.

**arteriosclerosis:** A generic name for several conditions that cause the walls of the arteries to become thickened, hard, and inelastic.

**artery:** A blood vessel, consisting of three layers of tissue and smooth muscle, that carries blood away from the heart.

**arthralgia:** Pain in a joint or joints.

**arthritis:** Inflammatory disease of the joints.

**articulation:** Joining of bones, a joint; touching of one part with another.

**artifact:** That which is artificial, out of place, introduced by human interference.

**artificial ventilation:** Movement of air into and out of the lungs by artificial means.

**ascending aorta:** That portion of the aorta beyond the aortic sinus and before its arch posteriorly.

**ascites:** An excessive accumulation of fluid in the abdominal cavity.

**asepsis:** Freedom from infectious agents.

**asphyxia:** Suffocation.

**aspirate:** To inhale foreign material into the lungs; to remove fluid or foreign material from the lungs or elsewhere by mechanical suction.

**aspirin:** Salicylic acid acetate; a drug known for its analgesic, fever reducing, and antirheumatic properties.

**asthma:** A condition marked by recurrent attacks of dyspnea with wheezing due to spasmodic constriction of the bronchi, often as a response to allergens, or by mucous plugs in the bronchioles.

**asymptomatic:** Without symptoms.

**asystole:** Having no contraction of the heart's ventricles.

**ataxia:** Failure of muscular coordination; often used to describe a staggering gait.

**atelectasis:** Collapse of the pulmonary alveoli.

**atherosclerosis:** A common form of arteriosclerosis caused by fat deposits in arterial walls.

**atlas:** The first cervical vertebra.

**atresia:** Absence of a normal opening.

**atrial:** Pertaining to one of the atria of the heart.

**atrial arrhythmias:** Disturbances of the heart's rhythm caused by malfunction of the sinoatrial node or ectopic focal activity in atrial tissue.

**atrial depolarization:** The electrical discharging of resting atrial muscles, produces the P wave of the EKG and produces atrial contraction.

**atrial fibrillation:** An arrhythmia characterized by discharge of the individual atrial muscle fibers, producing no distinct P wave, and a grossly irregular ventricular rhythm having no pattern; the QRS is narrow, within .12 seconds.

**atrial flutter:** An arrhythmia characterized by a persistent stimulus arising from a focus of atrial origin, or a circus movement within the atrium, producing atrial contractions 100 to 400 times per minute; ventricular response is regulated by the degree of refractory block in the AV node.

**atrial repolarization:** The electrical process of recharging the depolarized atrial muscle following contraction; represented on EKG by the atrial T wave, usually not seen because of the overwhelming electrical activity of the concurrent ventricular depolarization.

**atrial systole:** The period of atrial contraction that occurs before ventricular contraction.

**atrioventricular block:** A condition in which the passage of stimuli from the atrium through the AV node is hindered or prevented.

**atrioventricular node:** A cluster of specialized cells that retard the passage of the atrial stimulus toward the ventricles, allowing the atria to complete their contraction; located near the junction of the atrial septum with the ventricular septum, next to the septal leaflet of the tricuspid valve.

**atrium:** A thin-walled chamber of the heart; the right atrium receives venous blood from the venae cavae; the left atrium receives oxygenated blood from the pulmonary veins.

**atrophy:** A wasting away of specific tissue.

**atropine:** A drug of the parasympathetic blocker class; used to increase the heart rate in sinus bradycardia or in AV blocks by reducing the block.

**audio:** Relating to sound waves in the range that the human ear can hear; the sound component of a transmitted telemetry signal.

**auditory nerve:** The eighth cranial nerve, mediates hearing and balance.

**aura:** A premonitory sensation of impending illness, usually used in connection with an epileptic attack.

**auricle:** The external ear; ear flap; also atrium.

**auscultation:** The technique of listening for and interpreting sounds that occur within the body, usually done with a stethoscope.

**automatic reaction:** An action performed without conscious thought.

**automaticity:** The ability of pacemaker sites within the cardiac conduction fibers to initiate stimuli spontaneously.

**autonomic nervous system:** Part of the nervous system concerned with the regulation of bodily functions not controlled by conscious thought; composed of the sympathetic and parasympathetic systems.

**autotransfusion:** A transfusion effected by redirecting the patient's own blood from one part of the body to another.

**AV:** Abbreviation for atrioventricular.

**avulsion:** An injury that leaves a piece of skin or other tissue either partially or completely torn away from the body.

**axilla:** The armpit.

**axillary temperature:** A measured body temperature obtained by placing a thermometer in the axilla while holding the arm close to the body for a period of 10 minutes.

**axis:** The second cervical vertebra; a line around which a revolving body turns or about which a structure would turn if it did revolve.

## B

**Babinski reflex:** A reflex response of movement of the big toe; positive reflex is determined when, on stroking the sole, the toe turns upward; negative is determined by a downward or no movement of the toe.

**backbone system:** A communications system used to integrate a number of strategically located base stations into a regional communications system; thus, a mobile unit anywhere within the service or of the system can communicate with its control center.

**bag of waters:** The amniotic sac and its contained amniotic fluid.

**bag-valve-mask:** A portable artificial ventilation unit consisting of a face mask, one-way valve, and an inflatable bag; producing positive pressure ventilation.

**balanced salt solution:** A solution of water and salts formulated to match the composition of normal blood; sodium, potassium, and calcium should be in correct proportion as that of blood.

**ball-and-socket joint:** A joint wherein the distal bone has a rounded head (ball) that fits into the proximal bone's cup-like socket; the hip and shoulder joints, for example.

**band:** A term applied to a group of radio wave frequencies.

**bandage:** A material used to hold a dressing in place.

**barbiturates:** A class of drugs that produce a calming, sedative effect.

**basal cell:** The early keratocyte; a cell present in the basal layer of the epidermis.

**basal skull fracture:** A fracture involving the base of the cranium.

**base:** Alkaline: a compound that dissociates with formation of a hydroxyl ion ($OH^-$); a solution having a pH greater than 7.0.

**base station:** A station (transmitter, receiver, and station control) installed at a fixed location and used to communicate with mobile stations.

**basic life support:** Maintenance of the ABC's (airway, breathing, and circulation) without adjunctive equipment.

**bile ducts:** Any of the ducts that convey bile between the liver and the intestines, including hepatic, cystic, and common bile ducts.

**biliary system:** A ductal system consisting of the gallbladder and the bile ducts connecting the liver to the intestine.

**bilious:** Characterized by bile, or excess of bile; an archaic term for a syndrome of nausea, anorexia, vomiting and lethargy, usually remedied by a "dose of salts."

**biological death:** A condition present when irreversible brain damage has occurred, usually from 3 to 10 minutes after cardiac arrest.

**biomedical telemetry:** The transmission of biological data from a living subject to a monitoring point by means of radio or wire circuits.

**biopsy:** The removal of a small piece of tissue for microscopic examination.

**biotelemetry:** See biomedical telemetry.

**birth canal:** Uteral cervix and vagina.

**bivalent:** Having two like charges; calcium, for example, $C^{++}$

**bladder:** A membranous sac; commonly referring to the muscular membranous sac that stores urine.

**blanch:** To become white or pale.

**bleb:** A large flaccid blister, at least 1 centimeter in diameter.

**blind panic:** A type of panic in which an individual's judgment seems to disappear; seen in situations where there are mass casualties.

**blister:** A collection of fluid under or within the epidermis.

**blocker:** A drug that counteracts or inhibits the action of another drug or agent; atropine as a parasympathetic blocker.

**blood:** The fluid that circulates through the heart, arteries, capillaries and veins, carrying nutriment and oxygen to the body cells, removing waste products such as carbon dioxide and various metabolic products for excretion.

**blood clot:** A soft, coherent, jellylike mass resulting from the conversion of fibrinogen to fibrin, thereby entrapping the red blood cells and other formed elements within the fibrinic web.

**Battle's sign:** A contusion on the mastoid process of either ear; sign of a basilar skull fracture.

**bedding hook:** A tool used for prying and lifting.

**beeper:** A term applied to a selectively activated paging receiver usually carried in the pocket or on the belt; upon receiving a page specifically directed to it, the receiver emits a beeping sound.

**Benadryl:** Trade name for diphenhydramine hydrochloride, an antihistamine.

**bends:** Pain in the limbs and abdomen occurring as a result of bubbles of nitrogen in the blood; caused by too rapid decompression; caisson disease, decompression sickness.

**benign:** Not dangerous; noncancerous; nonmalignant.

**beta particle:** An electron, either positively charged (positron) or negatively charged (negatron), that is emitted during beta decay of a radionuclide.

**beta receptor:** A nerve center that reacts only to those compounds with molecules to fit the receptor cells; beta adrenergic receptors.

**beta stimulator:** Any agent that activates the beta receptors of the body; isoproterenol, for example; beta adrenergic compounds.

**bevel:** The slanting edges of the point of a needle.

**Benzadrine:** Brand name for amphetamine sulfate, a central nervous system stimulant.

**bicarbonate:** Any salt having two parts carbonic acid to one of any basic substance; often used as an abbreviated form of sodium bicarbonate; also bicarb.

**biceps:** The large muscle of the front part of the arm that bends the forearm at the elbow; also, one of the hamstring muscles located on the back of the thigh that flexes and rotates the knee.

**b.i.d.:** Abbreviation for *bis in die,* meaning twice a day.

**bifurcation:** A division into two branches; the point of such division.

**bigeminy:** A pattern of cardiac arrhythmias wherein there are two beats, one normal and one premature, commonly means ventricular bigeminy, one normal beat and one ventricular premature contraction.

**bile:** A fluid secreted by the liver that is concentrated and stored in the gallbladder and then discharged into the intestine where it aids in digestion of fats.

**blood pressure:** The pressure exerted by the pulsatile flow of blood against the arterial walls.

**diastolic blood pressure:** The blood pressure measured during ventricular diastole.

**systolic blood pressure:** The blood pressure measured during ventricular systole.

**blood type:** One of the several groups into which human blood is divided according to its antigens.

**blood volume:** The total amount of blood in the heart and blood vessels; represents 8 to 9 percent of body weight in kilograms.

**blood volume expander:** The synthetic solution administered intravenously to expand blood volume in the treatment of shock.

**bloody show:** The mucous and bloody discharge signaling beginning of labor.

**boltcutter:** A tool used to cut heavy metal.

**bolus:** A single, large, loading dose of a drug that provides an initial high therapeutic level in the blood.

**bone:** The hard form of connective tissue that constitutes most of the skeleton in a majority of vertebrates.

**bone suture:** The type of fibrous joint in which the close bony surfaces are so closely united by a very thin film of connective tissue that no movement can occur.

**bourdon gauge:** A calibrated pressure gauge used to record the flow rate of a medical gas from a compressed cylinder.

**bowel:** See intestine.

**BP:** Abbreviation for blood pressure.

**brachial artery:** The artery of the arm that is the continuation of the axillary artery, that in turn branches at the elbow into the radial and ulnar arteries.

**bradycardia:** An abnormally slow heart rate, usually any rate less than 60 beats per minute.

**brain:** A soft, large mass of nerve tissue that is contained within the cranium.

**brain contusion:** See cerebral contusion.

**brain stem:** The stemlike portion of the brain that connects the brain with the spinal cord; includes the pons, medulla, and mesencephalon.

**breech birth (breech delivery):** The delivery during which the presenting part of the fetus is the buttocks or foot instead of the head.

**bronchial asthma:** The common form of asthma.

**bronchiole:** Any of the smaller bronchi leading into the alveoli of the lung.

**bronchiolitis:** A condition seen in children under 2 years of age characterized by dyspnea and wheezing, a viral infection often confused with asthma.

**bronchitis:** Inflammation of the bronchi.

**bronchoconstriction:** A narrowing of the bronchial tubes.

**bronchodilation:** A widening of the bronchial tubes.

**bronchodilator:** An agent that causes the dilation of the bronchi and bronchioles.

**bronchospasm:** A severe constriction of the bronchial tree.

**bronchus:** One of the two main branches of the trachea that lead to the right and left lungs; any of the larger air passages of the lungs.

**bruise:** An injury that does not break the skin but causes rupture of small underlying blood vessels with resulting tissue discoloration; a contusion.

**buccal:** Pertaining to the cheek or mouth.

**buffer:** A substance in a fluid that tends to minimize changes in pH that would otherwise result from adding an acid or base to the fluid; the system of the body that corrects most acid-base imbalances, consists of the carbonate system, which eliminates hydrogen from carbonic acid, converting into bicarbonate anions.

**bundle branch block:** A disturbance in the conduction of the excitation stimulus through the right or left bundle branch from the AV bundle, or Bundle of His.

**Bundle of His:** The atrioventricular bundle; that portion of the Purkinje system leading out of the atrioventricular node and into the septum of the ventricles.

**burn:** An injury caused by heat, electrical current, and chemicals of extreme acidity or alkalinity.

**first degree burn:** A burn causing only reddening of the outer layer of skin; sunburn usually is a first degree burn.

**second degree burn:** A burn extending through the outer layer of skin, causing blisters and edema; A scald is usually a second degree burn.

**third degree burn:** A burn extending through all layers of skin, at times through muscle or connective tissue, having a white leathery look and is insensitive; grafting is more often necessary with a third degree burn; a flame burn is usually third degree.

**burn center:** A medical facility especially designed, equipped, and staffed to treat severely burned patients.

**buttock:** The prominence formed by the gluteal muscles on the posterior of both side of the body.

## C

**c:** Abbreviation for *cum;* with.

**cachexia:** A state of severe malnutrition and poor health as a result of disease or lack of nourishment.

**caisson disease:** See bends.

**calcium:** A mineral substance necessary for life functioning; plays a vital role in heart contraction, nerve conduction, and muscle contractions; cation with double valence.

**calcium chloride:** $CaCl_2$; used to restore electrolyte balance; used in severe cardiac dysfunction as a positive inotropic agent.

**cancer:** A malignant tumor; commonly any form of malignancy, including leukemia.

**cannula:** A tube, often fitted with a trocar, used to enter a duct or cavity.

**capillary:** Any one of the small blood vessels that connect arteriole and venule, and through whose walls various substances pass into and out of the interstitial tissues, and thence on to the cells.

**capsule:** A cylindrical gelatin container enclosing a dose of medication, usually in powdered form.

**carbohydrate:** A compound represented by the sugars, starches, and celluloses; contains carbon, hydrogen, and oxygen.

**carbon dioxide:** $CO_2$; a colorless and odorless gas that neither supports combustion nor burns; a waste product of aerobic metabolism; in combination with water ($H_2O$), forms carbonic acid ($H_2CO_3$).

**carbon monoxide:** CO; a colorless, odorless, and dangerous gas formed by the incomplete combustion of carbon; it combines four times as quickly with hemoglobin than oxygen; when in the presence of heme, replaces oxygen and reduces oxygen uptake in the lungs.

**cardiac:** Pertaining to the heart.

**cardiac arrest:** The sudden cessation of cardiac function with no pulse, no blood pressure, unresponsiveness.

**cardiac asthma:** A condition characterized by left heart failure and pulmonary edema with wheezing respirations; not related to bronchial asthma.

**cardiac compression:** A technique of external heart massage to restore the pumping action of the heart.

**cardiac cycle:** The interval from the beginning of one heart beat to the succeeding beat; each cardiac cycle includes ventricular contraction (systole) and relaxation (diastole).

**cardiac output:** The amount of blood pumped out by the heart per minute, computed by the following equation: Cardiac output = stroke volume times heart rate.

**cardiac standstill:** The absence of cardiac contraction or electrical activity.

**cardiac tamponade:** A condition resulting from excess fluid accumulation in the pericardium.

**cardiogenic:** Of cardiac origin.

**cardiogenic shock:** The inability of the heart to pump adequate amounts of blood to perfuse the vital organs.

**cardiopulmonary arrest:** The cessation of cardiac and respiratory activity.

**cardiopulmonary resuscitation (CPR):** The application of artificial ventilation and external cardiac compression in patients with cardiac arrest to provide an adequate circulation to support life.

**cardiotonic drugs:** A class of drugs that improves and strengthens myocardial contraction.

**cardiovascular:** Pertaining to the heart and blood vessels.

**cardiovascular collapse:** Failure of the heart and blood vessels; shock.

**cardioversion:** An application of synchronized direct current shock to the chest wall to convert ineffective arrhythmias to an effective rhythm.

**carina:** The point where the trachea bifurcates into the right and left mainstem bronchi.

**carotid artery:** The principal artery of the neck, palpated easily on either side of the thyroid cartilage.

**carotid sinus:** A dilated area in the internal carotid artery, usually found just superior to the bifurcation of the common carotid artery; contains baroreceptors and chemoreceptors.

**carotid sinus massage:** The application of fingertip pressure to the carotid sinus to convert various supraventricular tachyarrhythmias to a more effective rhythm; pressure causes parasympathetic stimulation to the heart, causing it to slow, or to stop, in some instances.

**carpals:** The eight small bones of the wrist.

**carpopedal spasm:** A muscular spasm of the hands and feet.

**cartilage:** A tough, elastic, connective tissue that covers opposite surfaces of movable joints and also forms parts of the skeleton, such as ear and nose.

**cartilaginous:** Relating to or consisting of cartilage.

**cataract:** The partial or complete opacity of the crystalline lens of the eye or its capsule.

**catecholamine:** A biologically active amine, such as epinephrine, norepinephrine and dopamine, which exerts a strong sympathetic action on the heart and peripheral blood vessels, thereby increasing cardiac output and blood pressure.

**catheter:** A tube used for withdrawing or infusing fluids into various structures of the body.

**catheter embolism:** The loss of a catheter fragment in a vein from shearing of an indwelling IV catheter.

**cation:** A positively charged ion, such as sodium ($Na^+$).

**caudad:** Toward the tail.

**caustic:** Corrosive, destructive to living tissue.

**cavity:** A hollow or space, especially a space within the body or one of its organs.

- **abdominal cavity:** The space bounded by the abdominal walls, the diaphragm, and the pelvis; contains most of the organs of digestion.

**cecum:** The pouchlike portion of the large intestine just inferior to the junction of the ileum and ascending colon; the vermiform appendix is attached on the inferior surface.

**cell:** A small cavity or compartment.

**Celsius scale:** See centigrade scale.

**centigrade scale:** The temperature scale in which the freezing point of water is zero degrees and the boiling point at sea level is 100 degrees; Celsius scale.

**centimeter:** A unit of measurement of the metric system, one one-hundredth of a meter; approximately two-fifths of an inch.

**central nervous system:** The portion of the nervous system consisting of the brain and spinal cord.

**central neurogenic hyperventilation:** An abnormal pattern of ventilation seen in severe illness or injury involving the brain; characterized by marked tachypnea and hyperpnea.

**central venous pressure:** The pressure of the blood in veins that aids in the return of blood to the heart; the pressure is much less than that of the blood in arteries; controlled by the blood volume and capacity of the veins.

**centrifugal force:** The force that tends to impel an object or its parts outward from the center of rotation.

**centripetal force:** The force that is necessary to keep an object moving in a circular path and that is directed inward toward the center of rotation.

**cephalic:** Pertaining to the head.

**cephalic delivery:** A delivery in which the head is the presenting part of the fetus; generally considered to be the normal mode of birth.

**cerebellum:** That portion of the brain behind and below the cerebrum; coordination is the general function.

**cerebral:** Pertaining to the brain.

**cerebral contusion:** A bruise of the brain, causing a characteristic symptomatic response.

**cerebral hemorrhage:** Bleeding into the cerebrum; one form of stroke or cerebrovascular accident.

**cerebrospinal fluid:** The fluid contained in the four ventricles of the brain and the subarachnoid space around the brain and spinal cord.

**cerebrovascular accident (CVA):** The sudden cessation of circulation to a region of the brain, due to thrombus, embolism, or hemorrhage; also, a stroke or apoplexy.

**cerebrum:** The portion of the brain controlling major functions of the body, including movement, sensation, thinking, and emotions.

**cervical:** Pertaining to the neck.

**cervical collar:** A device used to immobilize and support the neck.

**cervical spine:** The superior seven bones of the vertebral column, located in the neck.

**cervix:** The lower portion, or neck, of the uterus.

**Cesarean section:** The delivery of a fetus by means of an incision into the uterus, usually through the abdominal wall.

**channel:** The signal path through which a radio frequency flows; frequency.

**cheek:** The side of the face forming the lateral wall of the mouth.

**cheekbone:** The quadrilateral bone that forms the prominence of the cheek; the zygomatic or malar bone.

**chemotherapy:** The treatment of disease by drugs; particularly the treatment of malignancy by drugs.

**Cheyne-Stokes respiration:** An abnormal breathing pattern characterized by rhythmic increase and decrease in depth of ventilations, with regularly recurring periods of apnea; seen in association with central nervous system dysfunction.

**CHF:** Abbreviation for congestive heart failure.

**chief complaint:** The problem for which a patient seeks help, stated in a word or short phrase.

**chills:** A sensation of cold, with convulsive shaking of the body.

**cholesterol:** A fatty substance found in animal tissue, egg yolks, and in various oils and fats; thought to contribute to arteriosclerosis.

**cholinergic:** Pertaining to the type of chemical activity that is characteristic of acetylcholine.

**chordae tendineae:** Tendons that attach to the free edges of the leaflets of the mitral and tricuspid valves and to the papillary muscles.

**chronic:** Of long duration, or recurring over a period of time.

**chronic obstructive pulmonary disease (COPD):** A term comprising chronic bronchitis, emphysema, and asthma; an illness that causes obstructive problems in the airways.

**chronotropic:** Affecting the time or rate; applied especially to drugs whose administration affect the contraction rate of the heart.

**circulatory:** Pertaining to the heart and blood vessels.

**circulatory collapse:** The failure of the cardiac and peripheral circulation.

**circulatory system:** The body system consisting of the heart and blood vessels.

**circumduction:** Circular movement of a limb or eye.

**circus movement:** As it pertains to heart stimulation, the circus movement of a stimulus causes reentry of formerly depolarized cells that are repolarized enough to accept the stimulus and depolarize again, passing along the stimulus to cells that are, in turn, repolarized and accept the stimulus, and around it goes again, causing rapid stimulation of the heart.

**cirrhosis:** Chronic progressive fibrosis of the liver, often associated with heavy alcohol ingestion.

**clammy:** Damp and usually cool.

**clavicle:** The collarbone; attached to the uppermost part of the sternum at a right angle, and joins the scapular spine to form the point of the shoulder.

**clinical:** Pertaining to the patient.

**clinical death:** A term that refers to the lack of signs of life, when there is no pulse and no blood pressure; occurs immediately after the onset of cardiac arrest.

**clonic:** Pertaining to a spasm in which rigidity and relaxation succeed each other.

**closed fracture:** A fracture in which there is no laceration in the overlying skin.

**clot:** A semisolid mass of fibrin and cells.

**clubbing:** Proliferation of soft tissue about the terminal phalanges of fingers and toes, without osseous change.

**CNS:** Abbreviation for central nervous system.

**CO$_2$:** Chemical formula for carbon dioxide.

**coagulation:** The process of changing a liquid into a thickened or solid state; the formation of a clot.

**coalesce:** To unite, to mix, to fuse

**cocaine:** A crystalline alkaloid obtained from *Erythoxylon coca* (coca leaves) used as a topical anesthetic, but now used more often as a central nervous system stimulant; often abused.

**coccyx:** The lowest part of the backbone; composed of three to five small, fused vertebrae; also called the tailbone.

**coffee grounds vomitus:** A vomitus having the appearance and consistency of coffee grounds; indicates slow bleeding in the stomach and represents the vomiting of partially digested blood.

**coke:** Street name for cocaine; also colloquial for Coca-Cola, a popular soda drink, nonalcoholic and nonaddictive.

**colic:** Acute abdominal pain characterized by intermittent cramps; common in infants and young children; also, pertaining to the colon.

**Colles' fracture:** A fracture at the distal end of the radius; can be accompanied by a fracture of a small fragment of the ulnar styloid process.

**colloid:** An intravenous solution containing protein.

**colostomy:** The creation of an opening between the colon and the surface of the body to provide bowel drainage.

**coma:** A state of unconsciousness from which the patient cannot be aroused even by powerful stimulation.

**comatose:** In a state of coma.

**come-a-long:** A hand-operated winch of varying capacity (2-ton capacity is standard for ambulance equipment); used to effect forceful entry.

**comminuted fracture:** A fracture in which the bone ends are broken into many fragments.

**common bile duct:** The duct formed by the union of the common hepatic ducts and the cystic duct; empties into the duodenum.

**communicable disease:** A disease that is transmissible from one person to another.

**compensatory pause:** The longer than normal R–R interval occurring after a premature ventricular contraction; caused by the failure of the ventricle to contract after the atrial contraction which occurred during the PVC.

**complete heart block:** A third degree AV block; the stimulus that stimulates the atrial contraction does not cause the ventricles to contract because the AV node will not allow the stimulus to pass through; ectopic focus causes ventricular contraction.

**compliance:** The quality of yielding to pressure or force without disruption, or an expression of the measure of ability to do so; the ability of the lung to distend with air as it is forced into the airways.

**compound fracture:** An open fracture; a fracture in which there is an open wound of the skin and soft tissues leading down to the location of the fracture

**compress:** A folded cloth or pad used for applying pressure to stop hemorrhage or as a wet dressing.

**concave:** Rounded and somewhat depressed or hollowed out.

**concussion:** A violent jar or shock; the central nervous system injury results from the impact.

**conductivity:** The ability of muscle, including cardiac muscle to conduct a stimulus from one muscle fiber to another.

**conductor:** Any substance capable of transmitting a stimulus.

**condyle:** Rounded projection on a bone, may be covered by cartilage at the joining with another bone.

**confrontation:** The technique of mentioning to patients significant points in their conversation or behavior of which they may not have been aware; used in interviews with emotionally disturbed patients.

**congenital:** Referring to any condition that is present at birth.

**congestive heart failure:** Excessive fluid in the lungs or tissues caused by the failure of the ventricles to effectively pump blood.

**conjunctiva:** The delicate membrane that lines the eyelids and covers the exposed surface of the eyeball.

**connective tissue:** The tissue that binds together and supports the various structures of the body.

**conscious:** Capable of responding to sensory stimuli and having subjective experiences.

**consent:** An agreement by patients to accept treatment offered as explained by medical personnel.

- **implied consent:** An assumed consent given by an unconscious adult when emergency lifesaving treatment is required.
- **informed consent:** A consent given for treatment by a mentally competent adult who understands what the treatment will involve; can also be given by parent or guardian of a child, as defined by the State, or for a mentally incompetent adult.

**constrict:** To be made smaller by drawing together or squeezing.

**constricting band:** A band used to restrict the lymphatic flow of blood back to the heart.

**contagious:** A term that refers to a disease that is readily transmitted from one person to another.

**contagious disease:** An infectious disease transmissible by direct or indirect contact; now synonymous with communicable disease.

**contaminated:** A term used in reference to a wound or other surface that has been infected with bacteria; may also refer to polluted water, food, or drugs.

**contraction:** A shortening of muscle fiber.

**contractility:** The ability of any muscle fiber to contract when it is depolarized by a stimulus.

**contraindication:** Not indicated; a situation that prohibits the use of a drug or technique.

**contralateral:** On the opposite side.

**contusion:** A bruise; an injury that causes a hemorrhage in or beneath the skin but does not break the skin.

**convection:** The conveyance of heat in liquid or gaseous form by movement of heated particles (as when the warm air of a room ascends to the ceiling); the loss of body heat to the atmosphere when air passes over the body.

**conversion hysteria:** A condition in which psychic energy from a repressed idea is converted into physical symptoms.

**convex:** Rounded and somewhat elevated.

**convulsion:** A violent involuntary contraction or series of contractions of the voluntary muscles; a fit or seizure.

**COPD:** Abbreviation for chronic obstructive pulmonary disease.

**core temperature:** A body temperature measured centrally, from within the esophagus or rectum.

**corium:** The fibrous, inner layer of the skin, the true skin.

**cornea:** The transparent structure covering the pupil.

**cornified:** Converted into tough tissue; keratinized; used to describe the outermost layer of skin.

**coronary:** A term applied to the cardiac blood vessels that supply blood to the walls of the heart.

**coronary artery:** One of the two arteries arising from the aortic sinus to supply the heart muscle with blood.

**coronary artery disease:** A progressive narrowing and eventual obstruction of the coronary arteries by the atherosclerotic process.

**coronary bypass:** The surgical procedure whereby a graft of part of the external saphenous vein is used to pass by a blocked coronary artery.

**coronary occlusion:** An obstruction in the coronary artery that hinders the flow of blood to some part of the heart; may be caused by narrowing of the vessel by atheromatous plaque or by a clot or by spasm of the vessel itself.

**coronary thrombosis:** The blockage of a coronary artery by a clot.

**corticosteroid:** A class of drugs, similar to the naturally occurring steroid hormones, sometimes used to counteract inflammation.

**costal:** Pertaining to the ribs.

**costochondral:** Pertaining to a rib and its cartilaginous portion attached to the sternum.

**costovertebral angle:** The angle formed by the spinal column and the 12th ribs; the general anatomic location of the kidneys.

**countershock:** The application of direct current to the patient in order to counteract some dysrhythmia of the heart.

**CPR:** Abbreviation for cardiopulmonary resuscitation.

**cramp:** A painful spasm, usually of a muscle; a gripping pain in the abdominal area; colic.

**craniad:** Toward the head.

**cranial:** Pertaining to the skull.

**cranial nerves:** The 12 pairs of nerves connected directly with the brain.

**cranium:** Skull.

**cravat:** A special type of bandage made from a large triangular piece of cloth and folded to form a band; used as a temporary dressing for a fracture or wound.

**crepitus:** A grating sound heard and the sensation felt when the fractured ends of a bone rub together.

**crib death:** See sudden infant death syndrome.

**cricoid cartilage:** The thick ring-shaped cartilage inferior to the thyroid cartilage of the larynx.

**cricothyroid membrane:** The fibrous tissue between the superior thyroid cartilage and the inferior cricoid cartilage.

**cricothyrotomy:** An incision into the lower airway through the cricothyroid membrane.

**cricothyrotome:** A surgical instrument used to make an opening into the trachea through the cricothyroid membrane.

**crisis:** A critical turning point or juncture; applied to both medical and psychiatric problems.

**croup:** A common viral disease of children; characterized by spasm of the larynx and resulting upper airway obstruction.

**crowbar:** A long metal bar with a chisellike point at one end; used as a lever for prying.

**crowning:** The stage of birth when the presenting part of the baby is visible at the vaginal orifice.

**crystalloid:** A substance capable of crystallization that, in solution, may be diffused through animal membranes; does not contain protein molecules.

**CSF:** Abbreviation for cerebrospinal fluid.

**cumulative action:** Action of increased intensity evidenced after several portions of the drug are taken.

**cutaneous:** Pertaining to the skin.

**cutdown:** Surgical exposure of a vessel to insert a cannula for the purpose of administering fluids or other medications.

**CVA:** Abbreviation for cerebrovascular accident.

**cyanosis:** A blueness of the skin due to insufficient oxygen in the blood.

**cyclic:** Occurring periodically.

**cystic:** Pertaining to cysts; also to the urinary bladder.

# D

**D5W:** Abbreviation for dextrose 5 percent in water; a solution of 50 grams in 1000 milliliters water.

**D50W:** Abbreviation for a solution of dextrose 50 percent in water; 500 grams in 1000 milliliters water.

**Darvon:** A trade name for propoxyphene, a narcotic.

**decerebrate posture:** A posture assumed by a patient with severe brain dysfunction; characterized by extension and internal rotation of the arms and extension of the legs.

**decibel:** A unit of measurement signifying the degree of loudness of sound.

**decimal:** A system of expressing fractions based on the number 10.

**decompensation:** Failure of the heart to maintain sufficient circulation of the blood.

**decompression:** Removal of compression or pressure.

**decompression chamber:** A chamber of compressed air into which a person may be introduced to treat decompression sickness by recompressing the person and gradually lowering the pressure in the chamber to match the local atmosphere; also, hyperbaric chamber.

**decompression sickness:** Bends; a condition caused by nitrogen bubbles that have returned to a gaseous state becoming lodged in blood or body tissues; characterized by pain in joints and chest, itching of skin, pulmonary edema.

**decontaminate:** Remove foreign substance that could cause harm; frequently used to describe removal of radioactive material from person, clothing, or area.

**decorticate posture:** The posture assumed by patients with a lesion at the brainstem level or above; characterized by tightly flexed arms, clenched fists, and slightly extended legs.

**decubitus ulcer:** A bedsore; ulcer caused by lack of blood supply to an area because of the pressure exerted on it by the part pressing against the bedding.

**defecate:** To discharge feces from the rectum.

**defibrillation:** Removal of fibrillation; applying unsynchronized direct current electrical shock to terminate fibrillation.

**defibrillator:** Any agent or measure that causes fibrillation to cease.

**definitive care:** Care given that will actually reverse, or act as a medium to reverse, a pathologic condition.

**dehydration:** Loss of water and electrolytes; excessive loss of body water.

**delirium:** A mental disturbance characterized by illusions, hallucinations, excitement, physical restlessness, having a short duration.

**delirium tremens:** DT's, a form of insanity, often temporary, caused by alcohol poisoning; characterized by sweating, tremor, great excitement, precordial pain, anxiety, and mental distress; occurs usually following heavy alcohol intake.

**delusion:** A belief or feeling that has no basis in fact; seen in several types of mental illness.

**demand pacer:** An implanted or temporary electronic pacer that stimulates the heart only if the normal heart stimulus is absent.

**demand valve unit:** An intermittent, positive pressure breathing unit used to assist or control ventilation; with a manual control, it is acceptable emergency equipment.

**Demerol:** A trade name for meperidine hydrochloride, a synthetic narcotic.

**demulcent:** An agent, such as mucilage or oil, that soothes and relives irritation, especially of mucous membranes.

**dementia:** Progressive mental deterioration due to organic disease of the brain.

**denial:** The psychic defense mechanism of dealing with unwanted information or feelings by ignoring their existence.

**dependency:** The condition of requiring help or support from another.

**depolarization:** The first step in activating a muscle or nerve cell; the membrane changes polarity from an exterior positivity to negativity, caused by influx of sodium and calcium ions into the cell, expelling potassium; contraction or conduction, or both, occurs as a result of the change.

**depolarization wave:** A stimulus causing depolarization.

**depressant:** An agent that lowers functional activity, a sedative.

**depressed fracture:** A skull fracture with impaction, depression, or a sinking in of the fragments.

**depression:** A mental state characterized by feelings of dejection, psychomotor retardation, insomnia, or weight loss, often of delusional proportion.

**derm-:** Prefix meaning having to do with skin.

**dermis:** The inner layer of skin; contains the skin appendages, hair follicles, sweat glands, nerves, and blood vessels.

**dextran:** A water-soluble polysaccharide used as a synthetic plasma volume expander in infusions.

**dextrose:** A preparation obtained by the hydrolysis of starch; used as an intravenous nutrient; a sugar.

**diabetes:** A general term referring to disorders characterized by excessive urine excretion, excessive thirst, and excessive hunger.

**diabetes mellitus:** A systemic disease marked by lack of production of insulin, which causes an inability to metabolize carbohydrates, resulting in an increase in blood sugar.

**diabetic coma:** Loss of consciousness due to severe diabetes mellitus which has not been treated or to treatment which has not been adequately regulated.

**diagnosis:** The determination of the nature of a pathological condition.

**diagnostic signs:** The indications of a patient's physiologic state and the determinating factors for treatment.

**dialysis:** The passage of substances through a membrane; the process of removing undesirable factors from a fluid through a selectively permeable membrane.

**diaphoresis:** Profuse perspiration.

**diaphragm:** The flat group of muscles and tendons that separate the abdominal and thoracic cavities.

**diaphysis:** The shaft of a long bone.

**diarrhea:** The passage of frequent watery or loose stools.

**diastole:** The period of cardiac cycle in which the heart relaxes and the ventricles fill with blood.

**diazepam:** A tranquilizer and muscle relaxant drug sometimes used for treatment of seizures; trade name Valium.

**diffusion:** The process of spreading out without use of energy, as through a membrane as in dialysis.

**digestion:** The process by which food is converted into simple chemical substances that can be absorbed by the intestines.

**digestive tract:** The passage of tubes leading from the mouth and pharynx to the anus; the alimentary tract; mouth, pharynx, esophagus, stomach, small intestine, large intestine, rectum, and anus.

**digitalis:** A drug used in the treatment of heart disease, especially heart failure and some atrial arrhythmias; a cardiac glycoside from *digitalis purpura,* or purple foxglove, a common herb.

**digitalis toxicity:** A state caused by an overdose of digitalis marked by anorexia, nausea, vomiting, yellow or green vision, and by increasing AV block, premature contractions, bradycardia.

**dilatation:** The act of widening an orifice beyond its normal dimensions.

**dilated pupil:** An ocular pupil enlarged beyond its normal size.

**dilation:** The process of expanding or enlarging.

**Dilaudid:** The trade name for dihydromorphinone, a drug with analgesia of the narcotic variety, and a respiratory depressant.

**diplopia:** Double vision.

**direct current electric shock:** Electric shock derived from storage batteries, as opposed to electric shock derived from alternating current; preferred method of defibrillation.

**disc:** The cartilaginous pad between the vertebrae that separates and cushions them.

**discharge:** Setting free or liberation; release the electrical charge in defibrillation.

**disentanglement:** The freeing of an entrapped victim.

**dislocation:** The state of being misaligned; the displacement of the ends of two bones at their joint so that the joint surfaces are no longer in proper contact.

**disorganization:** A disturbed mental state characterized by the inability to estimate direction or location or to be aware of time or other people.

**dispatcher:** One who transmits calls to service units and sends vehicles and personnel on assignments.

**distal:** Farthest from any point on the center or median line; in extremities, farthest from the point of junction of the trunk of the body.

**distention:** The state of being inflated or enlarged, particularly of the abdomen.

**distortion:** The state of being twisted out of normal or natural shape or position.

**diuresis:** Increased secretion of urine.

**diuretic:** An agent used to increase the secretion of urine by the kidneys.

**diverticulitis:** Inflammation of a diverticulum of the colon.

**diverticulosis:** The presence of diverticula of the colon; having a small blind pouch off the lumen of the colon.

**DOA:** Abbreviation for dead on arrival.

**doll's eye reflex:** A test for brain damage wherein the eyes move in the same direction as the head is turned from side to side, as if the eyes were painted (doll's) eyes.

**dominant pacemaker:** That part of the cardiac conduction system that has control of the heart stimulus; normally the sinoatrial node.

**dorsal:** Toward the back.

**dorsalis pedis:** The artery whose pulse is palpated on the dorsal part of the foot (the instep).

**dorsiflexion:** The turning of the foot or toes upward.

**DOS:** Abbreviation for dead at the scene.

**drag:** A general term referring to methods of moving patients without a stretcher or litter, usually employed by a single rescuer.

- **blanket drag:** A method by which one rescuer encloses a patient in a blanket and then drags the patient to safety.
- **clothes drag:** A method by which one rescuer can drag a patient to safety by grasping the patient's clothes and pulling him away from danger.
- **fireman's drag:** A method by which one rescuer crawls with a patient, looping the patient's tied wrists over the rescuer's neck to support the patient's weight.

**drape:** A sterile covering used to cover an area that is to be operated on or examined; the material used for this purpose.

**dressing:** A protective covering for a wound; used to stop bleeding and to prevent contamination of the wound.

**dromotropic:** Affecting the conductivity of a nerve fiber, especially the cardiac conduction system; positive dromotropic describes a faster conduction than normal.

**droplet contract:** A means of transmitting a communicable disease indirectly by spray droplets from an infected person's coughing or sneezing.

**D.T.'s:** See delirium tremens.

**dumbcane:** A tropical American herb *(Dieffenbachia seguine)* that when chewed causes the tongue to swell, may be severe enough to threaten the airway.

**duodenum:** The segment of the small intestines that lies just distal to the stomach, said to be about twelve fingerbreadths in length.

**duplex:** A radiocommunications system employing more than one frequency.

**dura mater:** The outermost and strongest of the three meninges.

**dying heart:** A heart with feeble, ineffectual ventricular contractions; evidenced on EKG by greatly widened QRS complexes with electromechanical dissociation; asystole.

**dys-:** Prefix meaning bad, or difficult.

**dysarthria:** Imperfect articulation due to disturbance of muscular control caused by damage to central or peripheral nervous system.

**dysconjugate vision:** A condition in which the two eyes are not aligned, but stare in different directions.

**dysfunction:** Abnormal function of an organ or body part.

**dysmenorrhea:** Painful or difficult menstruation; menstrual cramps.

**dysphagia:** An inability to swallow or difficulty in swallowing.

**dyspnea:** Painful or difficult breathing; usually used to mean rapid, shallow respirations.

**dysrhythmia:** A disturbance in the cardiac rhythm.

## E

**eardrum:** A flexible membrane that forms most of the outer wall of the tympanic cavity and separates it from the external auditory canal; the tympanum.

**ecchymosis:** Blood under the skin causing a black and blue mark; bruise.

**ECF:** Abbreviation for extracellular fluid.

**ECG:** Abbreviation for electrocardiogram; also EKG.

**eclampsia:** A toxic condition of pregnancy, causing convulsions and coma, associated with hypertension, edema, and proteinuria.

**-ectomy:** Suffix meaning surgical removal, as in appendectomy.

**ectopic:** Out of place; located away from the normal position.

**ectopic focus:** A stimulus initiated away from the sinoatrial node.

**ectopic pregnancy:** A pregnancy in which the fetus is implanted elsewhere than in the uterus, e.g., in the fallopian tube or in the abdominal cavity; produces abdominal pain, bleeding.

**edema:** A condition in which fluid escapes into the body tissues from the vascular or lymphatic spaces and causes local or generalized swelling.

**EEG:** Abbreviation for electroencephalograph.

**EENT:** Abbreviation for eye, ear, nose and throat.

**efferent:** Conducting or progressing away from a center or specific site of reference.

**effusion:** A leakage of fluid from tissues into a cavity, such as into the pleural cavity.

**ejaculation:** A sudden act of expulsion; the expulsion of semen.

**EKG:** Abbreviation for electrocardiogram.

**electrocardiogram:** A graphic tracing of the electrical currents generated by the process of depolarization and repolarization of the myocardial tissues.

**electrocution:** Death caused by passage of electrical current through the body.

**electrode:** A probe used to sense electrical activity.

**electroencephalogram:** A recording of the electrical potentials on the skull generated by currents emanating spontaneously from nerve cells in the brain.

**electrolyte:** A substance whose molecules dissociate when put into solution.

**electrolyte imbalance:** A deviation from the normal concentrations of serum electrolytes due to excessive intake or loss of various electrolytes.

**electromechanical dissociation:** The state in which the electrical currents in the heart are active but the mechanical (contracting) action is not effectively pumping blood; the EKG complexes may be present, but there is no pulse.

**electron:** One of the subatomic particles, usually found negatively charged, circling the positively charged nucleus.

**elixir:** A liquid oral medication containing flavorings, sweetening, and alcohol.

**emaciation:** A wasted condition of the body; extreme leanness.

**emboli:** Plural of embolus.

**embolism:** The sudden blocking of an artery or vein by a clot or foreign material which has been brought to the site of lodgement by the blood current.

**embolus:** A clot or another plug brought by the blood from another vessel and forced into a smaller one, thus obstructing the circulation.

**embryo:** In animals, the derivatives of the fertilized egg, that eventually become offspring, during their period of most rapid development, in man, from about 2 weeks after fertilization to the end of the seventh or eighth week.

**emesis:** Vomiting.

**emetic:** An agent that causes vomiting.

**emphysema:** A chronic lung disease caused by distention of the alveoli and/or destruction of their walls; a pathological accumulation of air in tissues, or organs, as in subcutaneous emphysema.

**EMS:** Emergency Medical Services.

**EMT:** Emergency Medical Technician.

**EMT–A:** Emergency Medical Technician-Ambulance.

**EMT–I:** Emergency Medical Technician-Intermediate.

**EMT–P:** Emergency Medical Technician-Paramedic.

**emulsion:** A preparation of one liquid distributed in small globules throughout the body of a second liquid; used as a lubricant.

**encephalitis:** Inflammation of the brain.

**encephalopathy:** Any disorder of the brain.

**endobronchial:** Within the bronchus or bronchi.

**endocardium:** The membrane lining the inside of the heart.

**endocrine:** Secreting internally.

**endoscope:** An instrument for the examination of the interior of a hollow organ, such as the stomach or bladder.

**endosteum:** The tissue lining the medullary cavity of bone.

**endothelium:** The layer of epithelial cells that lines the cavities of the heart and the blood and lymph vessels, and the serum-producing lining of the cavities of the body.

**endotracheal:** Within or through the trachea, an endotracheal tube.

**endotracheal intubation:** The insertion of a tube through the mouth or nose and into the trachea.

**endotracheal tube:** One of a series of graduated tubes, with or without inflatable cuffs, to be inserted in the trachea for the purpose of maintaining an airway and/or delivery of oxygen.

**enteritis:** An inflammation of the small intestine, usually accompanied by diarrhea.

**enterocolitis:** Inflammation of the small intestine and colon.

**envenomation:** The poisonous effects caused by the bites, stings, or deposits of insects, spiders, snakes, or other poison-carrying animals.

**enzyme:** A protein substance capable of accelerating or producing by catalytic action some change in another substance for which it is often specific.

**EOA:** Abbreviation for esophageal obturator airway.

**epi-:** Prefix meaning on top of or above.

**epicardium:** The serous layer of pericardium covering the outside of the heart.

**epicondyle:** A projection above a condyle, as the epicondyle on the humerus, medial projection of the elbow.

**epidemic:** An occurrence of a disease among many people over a given area.

**epidermis:** The outermost and nonvascular layer of the skin.

**epidural:** Located outside or above the dura, the outermost membrane that covers the brain.

**epigastrium:** The upper and middle regions of the abdomen within the costal angle.

**epiglottis:** The lidlike cartilaginous structure overhanging the superior entrance to the larynx and serving to prevent food from entering the larynx and trachea while swallowing.

**epiglottitis:** A bacterial infection occurring in children, marked by swelling of the epiglottis, high fever, pain on swallowing, and drooling; airway obstruction can result with great rapidity.

**epilepsy:** A chronic brain disorder marked by paroxysmal attacks of brain dysfunction, usually associated with some alteration of consciousness, abnormal motor behavior, psychic or sensory disturbances; may be preceded by aura.

**epinephrine:** A hormone released by the adrenal medulla which stimulates the sympathetic nervous system, producing vasoconstriction, increased heart rate and bronchodilation.

**epiphyseal injury:** An injury that results in a break of a bone at the cartilaginous epiphysis, a growth center, at the end of a long bone, producing possible deformity or stunting of that bone.

**epiphyseal plate:** The disc of cartilage between the shaft and the epiphysis of a long bone that exists during the growth of the bone.

**epiphysis:** Either end of a long bone.

**epistaxis:** Nosebleed.

**epithelium:** The purely cellular, avascular layer covering all the free surface of the body; cutaneous, mucous, and serous functions.

**erectile tissue:** The tissue containing large vascular spaces that fill with blood on stimulation, such as the penis, clitoris, and nipple.

**erythema:** A redness of the skin produced by congestion of the capillaries.

**erythrocyte:** A red blood cell.

**eschar:** A thick, coagulated crust or slough that develops after a thermal burn, cauterization, or laceration of the skin; a scab.

**esophageal obturator airway:** A device used to provide an adequate airway by blocking off the esophageal opening with a cuffed obturator and providing ventilation through a series of side holes located at the level of the epiglottis.

**esophagus:** The portion of the digestive tract that lies between the pharynx and the stomach.

**estrogen:** One of the classes of female sex hormones.

**ethanol:** Ethyl alcohol, the type of alcohol present in alcoholic beverages.

**ethmoid:** Bone found at the roof of the nose, the base of the cranium, and between the eyes; through it pass the olfactory nerves.

**etiology:** The study of the factors that cause disease.

**euphoria:** A feeling of well-being and happiness.

**eustachian tube:** The tube leading from the back of the throat to the middle ear; serves to equalize pressure in the middle ear.

**evaporation:** Conversion of a liquid or solid to a gas.

**evert:** To turn inside out; to turn outward.

**eviscerate:** To remove or expose the intestines.

**exacerbation:** A relapse or worsening of a disease condition.

**excitability:** The capability of any cell to be stimulated to act.

**excitation stimulus:** An electrical stimulus that arises through the physiologic capability of the heart's conduction system and that causes the depolarization and consequent contraction of the fibers.

**excoriation:** Any superficial loss of substance, such as that produced on the skin by scratching.

**excretion:** The process whereby the residue of food and waste products of metabolism are eliminated.

**exhalation:** The act of breathing out; expiration.

**exophthalmus:** Abnormal protrusion of the eye.

**exostosis:** A benign new growth protruding from the outer contour of bones and characteristically capped by growing cartilage.

**expectorant:** A drug that loosens and facilitates the removal of secretions in the bronchial tubes.

**exsanguinate:** To bleed to death.

**extender:** A person who can help the medical professional by performing some emergency medical procedures when the professional cannot be on the scene. Citizens who are taught first aid and CPR techniques are extenders for the EMT-P; EMT-Ps are extenders for the physician.

**extension:** The process of straightening; the movement by which the two ends of any joined part are drawn away from each other.

**external cardiac compression:** The method by which mechanical depression of the lower half of the sternum compresses the ventricles and forces blood into the systemic and pulmonary circulation.

**extracellular fluid:** The portion of the total body water outside the cells, composed of the interstitial and intravascular fluid.

**extract:** A concentrated preparation of a drug prepared by dissolving the drug in alcohol or water and evaporating off the excess solvent to a prescribed standard.

**extraoculular motions:** The movement of the eyes.

**extrasystole:** An extra heartbeat, often a premature contraction.

**extravasation:** A discharge or escape, as of blood from a vessel into the tissues.

**extremity:** A limb, an arm, or a leg.

**extrication:** Disentanglement; freeing from entrapment.

**extruded:** Pushed out of normal position.

**exudate:** Material, such as cells, fluids, deposited in tissues or on tissue surfaces, usually as result of inflammation.

**eyelid:** Either of the two movable conjunctival-cutaneous folds that protect the anterior surface of the eyeball.

## F

**facemask:** A device used for the administration of gases, particularly oxygen, or for the redirection of room air, as in the esophageal obturator airway.

**facies:** The expression or appearance of the face that can be characteristic of various disease conditions.

**facilitation:** The technique of encouraging patients to communicate by small positive responses, such as nodding the head or saying "I see."

**Fahrenheit scale:** The temperature scale in which the freezing point is 32 degrees and the boiling point at sea level is 212 degrees.

**fainting:** A momentary loss of consciousness caused by insufficient blood supply to the brain; syncope.

**fallopian tube:** The bilateral tubes extending from the ovaries to the uterus.

**false motion:** A motion of an extremity or a part of the body where ordinarily there should be none, indicative of a fracture or dislocation.

**fascia:** A sheet or band of fibrous tissue; lies deep under the skin and acts as an anchor for muscle attachment.

**fatigue fracture:** A fracture in which the bone breaks as a result of repeated stress that cannot be tolerated by that particular bone; most likely involving bones of feet or legs.

**fatty acid:** Any acid derived from fats by hydrolysis.

**FCC:** Abbreviation for Federal Communications Commission.

**febrile:** Pertaining to fever.

**feces:** The product expelled by the bowels; semisoft waste products of digestion.

**Federal Communications Commission:** The principal regulatory agency that assigns radio frequencies and licenses individuals and communications systems.

**femoral:** Pertaining to the femur or thigh bone.

**femoral artery:** The principal artery of the thigh, a continuation of the iliac artery; supplies blood to the lower abdominal wall, the external genitalia, and the lower body extremities; pulse may be palpated in the groin area.

**femoral head:** The rounded protuberance at the proximal end of the femur; fits into the acetabulum of the innominate bone to make the hip joint.

**femoral pulse:** Located approximately two fingerbreadths inferior to the midpoint of a line between the anterior superior iliac spine and the pubic symphysis.

**femur:** The bone that extends from the pelvis to the knee; the longest and largest bone of the body; the thigh bone.

**fetal death certificate:** The certificate required when a baby is born dead (stillbirth); most states regard stillbirths of less than 20 weeks pregnancy as abortions and may or may not require registration of a birth.

**fetus:** The unborn offspring in the postembryonic period after major structures have been outlined; in man from 7 or 8 weeks after fertilization until birth.

**fever:** An elevation of body temperature beyond normal.

**fibrillation:** Asynchronous, uncoordinated contraction of individual muscle fibers, producing no effective contraction.

**fibrillatory waves:** On the EKG, the waves that appear as numerous, dissimilar, and irregularly shaped, rounded waves caused by chaotically firing multiple ectopic foci or multiple circus movements in muscle bundles.

**fibrosis:** The formation of fibrous tissue that causes scarring, usually as part of a reparative or reactive process.

**fibula:** The smaller of the two bones of the lower leg; the most lateral bone of the lower leg.

**first responder:** A person who arrives first at the scene of a medical emergency, usually police or firefighters.

**fissure:** A narrow slit or cleft, especially one of the deeper or more constant furrows separating the gyri of the brain.

**fistula:** A deep sinuous passage or tract, often leading to an internal hollow organ.

**flaccid:** A term meaning soft, limp, without any muscular tone.

**flail chest:** A condition in which several ribs are broken, each in at least two places; or a sternal fracture or separation of the ribs from the sternum producing a free-floating segment of the chest wall that moves paradoxically on respiration.

**flail segment:** That segment of the chest wall, in a flail chest injury, lying between the rib fractures and moving paradoxically with respiration.

**flatulence:** Excessive formation of gases in stomach or intestine.

**flexion:** The act of bending, or the condition of being bent.

**flowmeter:** A device used to measure the rate of any agent introduced into a patient; specifically, used in connection with the use of oxygen.

**flow rate:** The rate at which oxygen flows from a cylinder; the rate at which an intravenous infusion is administered.

**flutter waves:** Sawtooth waves, as atrial depolarizations, on EKG, indicative of atrial flutter.

**follicle:** A deep, narrow pit in the skin containing the root of the hair; the duct of the sebaceous gland opens into the follicle.

**fontanel:** One of the membrane-covered spaces remaining at the junction of the sutures in an incompletely ossified skull; a baby's soft spot on his skull.

**foot-drop:** A paralysis of the dorsiflexor muscles of the foot and ankle; the foot falls and the toes drag on the ground when walking.

**foramen:** Any natural opening through a bone or other structure of the body; plural: foramina.

**forearm:** The part of the upper extremity between the elbow and the wrist.

**foreskin:** The free fold of skin that covers the glans penis more or less completely.

**Fowler's position:** The head of the patient is raised 18 to 20 inches above level, with the knees of the patient raised also.

**fracture:** A break or rupture in a bone.

**closed fracture:** A simple fracture, one that does not cause a break in the skin.

**comminuted fracture:** A fracture in which the bone is shattered, broken into small pieces.

**compound fracture:** An open fracture, one in which the bone ends pierce the skin.

**greenstick fracture:** An incomplete fracture, the bone is not broken all the way through, seen most often in children.

**impacted fracture:** A fracture in which the ends of the bones are jammed together.

**oblique fracture:** A fracture in which the break crosses the bone at an angle.

**open fracture:** A compound fracture, one in which the skin is opened.

**simple fracture:** A closed fracture, one in which the skin is not broken.

**spiral fracture:** A fracture in which the break line twists around and through the bone.

**transverse fracture:** A fracture in which the break line extends across the bone at right angle to the long axis.

**fracture-dislocation:** A fracture of a bone near an articular with a concomitant dislocation at that joint.

**fracture of the hip:** A fracture that occurs at the upper end of the femur, most often at the neck of the femur.

**frequency:** The number of waves per unit of time; also the number of occurrences of an illness per unit of time.

**frequency modulation:** A method of converting an analog signal into a tone of varying pitch that can be transmitted over the radio.

**frontal:** Pertaining to the forehead region; of the frontal bone; the position of facing straight ahead; the plane that divides the body into front and back parts.

**frontal lobe:** The portion of the brain under the frontal bone.

**frost nip:** The superficial local tissue destruction caused by freezing; limited in scope and does not destroy the full thickness of skin.

**frostbite:** The damage to tissues as a result of prolonged exposure to extreme cold.

**fungus:** Any vegetable organism of the class to which mushrooms and molds belong, many classes being pathogenic for man.

**furosemide:** A potent diuretic agent used in the treatment of congestive heart failure and hypertension; trade name Lasix.

**fuse:** To unite or join together.

**fused joint:** A joining of bones to form a rigid structure, as in the skull or sacrum.

## G

**gaining access:** Establishing a means of reaching the patient who is entangled in some problematic situation.

**gait:** The manner in which a person walks.

**galea aponeurotica:** The fibrous aponeurosis connecting the occipitalis muscle posteriorly and the frontalis muscle anteriorly; the tissue underlying the scalp and covering the skull.

**gallbladder:** The sac located just beneath the liver that concentrates and stores bile.

**gamma rays:** An electromagnetic radiation emitted from radioactive substances analogous to x-rays.

**ganglion:** A knot or mass; a group of nerve cell bodies located outside the central nervous system.

**gangrene:** Local tissue death as the result of an injury or inadequate blood supply.

**gas gangrene:** A disease originating in a wound infected with *Clostridium perfringens;* results in rapid tissue destruction.

**gastric:** Pertaining to the stomach.

**gastric juice:** The digestive fluids secreted by the stomach; a thin colorless liquid that has an acid reaction; contains mainly hydrochloric acid, pepsin, and mucus.

**gastrointestinal:** Pertaining to the stomach and intestine.

**gastrointestinal tract:** The digestive tract, including stomach, small intestine, large intestine, rectum, and anus.

**gauge:** A term that refers to the diameter of a needle or a needle cannula.

**Geiger counter:** An instrument consisting of a Geiger-Muller tube and the electronic equipment used in conjunction with it; records the current pulsations produced by the passage of radioactive particles within the tube gas.

**generic name:** The name given to a drug by the company that first manufactures it; usually a simplified version of the chemical name.

**genital system:** The system including all the reproductive organs.

**genitalia:** The external sex organs.

**genitourinary system:** The system including all the organs involved in reproduction and in the formation and voiding of urine.

**geriatric:** A term that refers to the elderly.

**germicidal:** Destructive to germs (microbes).

**gestation:** The period of development of the young; pregnancy.

**gigahertz:** A unit of frequency equalling 1 billion Hertz; indicates frequencies of 1 billion cycles per second.

**gland:** An organ or any cell group that produces a secretion not related to its ordinary needs.

**Glasgow Coma Scale:** A method of quantifying a patient's state of consciousness.

**glaucoma:** A disease that produces increased pressure within the eyeball; can lead to blindness.

**glenohumeral joint:** The shoulder joint; the joint between the upper end of the humerus and the scapula.

**glenoid fossa:** The hollow in the head of the scapula that receives the head of the humerus to create the shoulder joint.

**globulin:** One of a class of simple proteins that are insoluble in water, soluble in dilute salt solution, and precipitated by ammonium sulfate; found in human serum and tissue and in seeds and nuts.

**glomerulus:** A small tuft or cluster, as of blood vessels or nerve fibers; specifically, the cluster of blood vessels projecting into the capsule of each of the urine-producing tubules of the kidney.

**glottis:** The vocal apparatus of the larynx, consists of the true vocal cords and the opening between them.

**glucose:** A simple sugar.

**glycogen:** The form in which carbohydrates are stored in animal and human tissue.

**glycolysis:** The breaking down of sugars into simpler compounds.

**goiter:** Enlargement of the thyroid, causing a swelling in the neck, caused by iodine deficiency in the diet.

**gonad:** An ovary or testis.

**gonorrhea:** A contagious inflammation of the genital mucous membrane; the most common veneral disease.

**gram:** The unit of weight of the metric system.

**grand mal:** A type of epileptic attack; characterized by a short-term, generalized, convulsive seizure.

**granuloma:** Any one of a large group of distinctive focal lesions that are granulelike or nodular; formed as a result of inflammatory reactions and ordinarily persist in the tissue as slowly smoldering inflammations.

**gravid:** Pregnant.

**groin:** The inguinal region; junction of the abdomen and the thigh.

**G-suit:** An inflatable coverall suit that can be used to exert general body compression; used by pilots.

**gtt:** Abbreviation for drops.

**gullet:** Esophagus; the passage from the pharynx to the stomach.

**gums:** The dense fibrous tissue covered by mucous membrane holding the teeth in place; envelopes the alveolar processes of the upper and lower jaws and surrounds the necks of the teeth.

## H

**habituation:** A situation in which a patient produces a tolerance to a drug and becomes psychologically dependent on the drug.

**half-ring splint:** A traction splint with a hinged half-ring at the upper end that allows the splint to be used on either right or left leg.

**hallucination:** A sensory perception not founded on objective reality; may involve smell, touch, taste, sight, and hearing.

**hallucinogen:** A drug or agent that has the capacity to induce hallucinations.

**Hgb:** Abbreviation for hemoglobin.

**HCT:** Abbreviation for hematocrit.

**headband:** A band used to secure a patient's head to a spineboard.

**head-tilt maneuver:** A procedure for opening the airway to relive obstruction caused by the tongue; with one hand beneath the patient's neck and one hand on the patient's forehead the neck is lifted and the head is tilted backward as far as possible; not recommended in patients with possible neck injury.

**heart:** A hollow muscular organ that receives the blood from the veins, sends it through the lungs to be oxygenated, then pumps it to the arteries.

**heart attack:** A layman's term for a condition resulting from blockage of a coronary artery and subsequent death of part of the heart muscle; an acute myocardial infarction; a coronary.

**heat cramps:** A painful muscle cramp resulting from excessive loss of salt and water through sweating.

**heat exhaustion:** A prostration caused by excessive loss of water and salt through sweating; characterized by clammy skin and a weak, rapid pulse.

**hematemesis:** A condition in which the patient vomits blood.

**hematochezia:** The passage of grossly bloody stools or bright red blood from the rectum.

**hematocrit:** The percentage of red blood cells in the total blood volume.

**hematoma:** A localized collection of blood in an organ, tissue, or space as a result of injury or a broken blood vessel.

**hematuria:** Blood in the urine.

**hemic hypoxia:** A condition of insufficient oxygen in the blood that is related to a diminished capacity of the red blood cells to carry oxygen.

**hemiparesis:** A weakness on one side of the body.

**hemiplegia:** Paralysis of one side of the body.

**hemithorax:** Refers to one side of the chest.

**hemodialysis:** The process of removing certain noxious agents from the blood by diffusion through a semipermeable membrane.

**hemoglobin:** The oxygen carrying substance of the red blood cells; when it has absorbed oxygen in the lungs, it is bright red and called oxyhemoglobin; after it has given up its oxygen to the tissues, it is purple in color and is called carboxyhemoglobin.

**hemolysis:** The disintegration of the red blood cells due to an adverse factor, such as transfusion reaction or snakebite.

**hemophilia:** An inherited blood disease occurring mostly in males, characterized by the inability of the blood to clot.

**hemopneumothorax:** The accumulation of air and blood in the pleural cavity.

**hemoptysis:** Coughing up blood from the lungs.

**hemorrhage:** Abnormally large amount of bleeding.

**hemorrhagic shock:** A state of inadequate tissue perfusion due to blood loss.

**hemostasis:** The stopping or slowing of a hemorrhage; the method of stopping hemorrhage.

**hemostat:** An instrument for stopping hemorrhage by compressing the bleeding vessel; a type of clamp.

**hemothorax:** Bleeding into the thoracic cavity.

**heparin:** A mucopolysaccaride acid, occurring naturally in tissues, but most abundant in liver and lung; a drug to prevent clotting, used in embolism and other clotting problems.

**hepatic:** Pertaining to the liver.

**hepatitis:** Inflammation of the liver.

**hepatomegaly:** A condition of having an enlarged liver.

**hernia:** The abnormal protrusion of any organ through an opening into another body cavity; most common is the inguinal hernia where a loop of intestine descends into the inguinal canal in the groin.

**heroin:** An alkaloid prepared from morphine by acetylization; formerly used for relief of coughs; because of the great danger of addiction following use of the drug, its manufacture and importation into the United States is prohibited.

**Hertz (Hz):** A unit of frequency measurement; 1 Hertz equals one cycle per second.

**Hg:** Chemical symbol for mercury.

**hiatus hernia:** A protrusion of the stomach into the mediastinum through an opening in the diaphragm; can cause chest pain similar to angina pectoris or that of acute myocardial infarction.

**hinge joint:** A specialized joint found in the elbow, knee.

**hip:** The lateral prominence of the pelvis from the waist to the thigh; more strictly, the hip joint.

**hip joint:** The ball and socket joint formed by the articulation of the head of the femur and the acetabular fossa.

**histamine:** A decomposition product of histidine, formed in the intestines and found in most body tissues or produced synthetically; it causes dilation and increased permeability of capillaries and stimulates gastric secretion and visceral muscle contraction.

**history:** Information about the patient's chief complaint, symptoms, data leading up to the acute episode, previous illnesses, family history, and surgical history.

**hives:** Red or white raised patches on the skin, often attended by severe itching; a characteristic reaction in allergic responses.

**homeostasis:** A tendency toward stability in the body's internal environment; a return to normal after any deviation.

**homocide:** The act of deliberately taking another person's life.

**hormone:** A substance secreted by an endocrine gland that has effects upon other glands or systems of the body.

**host:** The organism that a parasite lives in or on.

**hostility:** A strong dislike, anger, or resistance toward an individual, group, or idea.

**hot sticks:** Wooden sticks that are rendered nonconductive by special treatment, used to manipulate charged electric wires.

**hot wire:** A wire through which an electric current is passing; a live wire.

**h.s.:** Abbreviation for *hora somni,* bedtime.

**humerus:** The bone of the upper arm.

**humidification:** The process of adding water to a gas or to the atmosphere, making the gas or atmosphere moist.

**humidifier:** A device used with an oxygen supply to moisten the oxygen and to prevent its drying effect on the mucous membranes of the patient.

**humor:** The extracellular fluids of the body; also, mirth.

**hydration:** The state of water balance in the body.

**hydraulic-powered unit:** A hand-operated hydraulic device used with attachments for raising, pushing apart, or pulling of vehicles or material; useful in reaching and extricating trapped victims.

**hydrochloric acid:** The acid in gastric juice.

**hydrothorax:** Fluid in the chest cavity.

**hygroscopic:** Taking up and retaining water readily.

**hyoid bone:** A U-shaped bone in the throat located above the larynx at the base of the tongue; provides the means to open the airway by lifting the mandible.

**hyper-:** Prefix meaning excessive, or increased.

**hyperactive:** A term meaning excessively or pathologically active.

**hyperalimentation:** The administration of greater than optimal amounts of nutrients; needed in pathologic states requiring large amounts of calories for regeneration of damaged tissue.

**hypercapnia:** Excess of carbon dioxide in the blood.

**hypercarbia:** An excessive amount of carbon dioxide in the blood; a carbon dioxide pressure greater than 45 to 50 torr.

**hyperemia:** An increased blood flow to a part of the body.

**hyperextend:** An overextension of a limb, or other part of the body.

**hyperflexia:** An overactive reflex.

**hyperglycemia:** An abnormally increased concentration of sugar in the blood.

**hyperkalemia:** An excessive amount of potassium in the blood.

**hypernatremia:** Excess of sodium (Na) in the blood.

**hyperpnea:** An increased depth of respiration.

**hyperpyrexia:** An abnormally high fever; hyperthermia.

**hyperresonance:** An abnormally increased resonance to percussion.

**hypersensitivity:** A reaction to contact with certain substances; allergy.

**hypertension:** High blood pressure, usually in reference to a diastolic pressure greater than 90–95 mm Hg.

**hyperthermia:** An abnormally increased body temperature; hyperpyrexia.

**hypertonic:** A solution having an osmotic pressure greater than a solution to which it is being compared (usually the intracellular fluid, or plasma).

**hypertrophy:** The morbid enlargement or overgrowth of any organ or part due to an increase in the size of its constituent cells.

**hyperventilation:** An increased rate and depth of breathing resulting in an abnormal lowering of arterial carbon dioxide, causing alkalosis.

**hypervolemia:** Abnormally increased volume as of the blood.

**hyphema:** Hemorrhage within the anterior chamber of the eye.

**hypnotic:** A medication causing sleep.

**hypo-:** A prefix meaning less than, lack of, a deficiency.

**hypoalimentation:** Insufficient nourishment.

**hypocapnia:** Too little carbon dioxide in the blood.

**hypocarbia:** An abnormally low carbon dioxide tension in the blood.

**hypochondriasis:** Anxiety about one's health, with complaint of minor disorders.

**hypoglycemia:** An abnormally diminished concentration of sugar in the blood; insulin shock.

**hypokalemia:** A low concentration of potassium in the blood.

**hyponatremia:** Too little sodium in the blood.

**hypopharynx:** The lowest part of the pharynx leading to the larynx and esophagus.

**hypopnea:** Abnormal decrease in depth and rate of breathing.

**hyposensitive:** Less sensitive than normal.

**hypotension:** Low blood pressure.

**hypothalamus:** The portion of the brainstem that activates, controls, and integrates peripheral autonomic mechanisms, endocrine activity, water balance, and automatic functions, such as sleep.

**hypothermia:** Decreased body temperature.

**hypotonic:** A solution having an osmotic pressure less than a solution to which it is being compared (usually the intracellular fluid, or plasma).

**hypoventilation:** A reduced rate and depth of breathing resulting in a rise in arterial carbon dioxide pressure, acidosis.

**hypovolemia:** A decreased amount of blood in the body.

**hypovolemic shock:** Shock caused by a reduction in blood volume, such as caused by hemorrhage.

**hypoxemia:** A term that refers to inadequate oxygen in the blood; an arterial oxygen pressure of less than 60 torr.

**hypoxia:** A low oxygen content in the blood; lack of oxygen in inspired air.

## I

**ICF:** Abbreviation for intracellular fluid.

**icterus:** Jaundice; the yellow appearance of the skin and other tissues due to the accumulation of bile pigments; seen in liver disease.

**idiopathic:** Of unknown cause.

**idiosyncrasy:** Anything that is peculiar to the individual; an unusual reaction to a drug, food, idea, action, or substance that is peculiar to the individual.

**idioventricular:** Of, or relating to, or affecting the cardiac ventricle only; an idioventricular rhythm is one that arises in the ventricle.

**ileocecal valve:** The protrusion of the terminal ileum into the large intestine at the ileocolic junction; protects the terminal ileum from feces forced back from the cecum.

**ileum:** The most distal portion of the small intestine lying between the jejunum and the colon.

**ileus:** An intestinal obstruction commonly caused by paralysis of bowel motility caused by peritonitis or other inflammatory process.

**ilium:** Either of the two broad uppermost portions of the hip bone.

**IM:** Abbreviation for intramuscular.

**immersion feet:** A disorder of the feet following prolonged immersion in water; when first removed from the water, the patient's feet are swollen, cold, waxy white with cyanotic areas, and anesthetic; a short time later the parts become red and hot and the swelling increases.

**immobilization:** To hold a part firmly in place, as with a splint.

**immobilize:** To make incapable of moving.

**immune:** Resistant to an infectious disease.

**immunization:** The process or procedure by which resistance is produced in a living organism; vaccination.

**impaled object:** An object that has caused a puncture wound and remains embedded in the wound.

**incision:** A wound usually made deliberately in connection with surgery; a clean cut as opposed to a laceration.

**incompatibility:** In blood typing, the situation in which donor and recipient blood cannot be mixed without clumping or other adverse reactions.

**incomplete AV block:** A delay or intermittent disturbance in the conduction of the stimulus from the atria to the ventricles, occurring in the AV junction, AV node, bundle of His, or bundle branches; causes prolongation of the P–R interval or absent QRS complexes, in the presence of regularly appearing P waves; first or second degree block.

**incontinence:** An inability to prevent the release of urine or feces.

**incubation:** The time period between exposure to an infection and the appearance of the first symptoms.

**incubator:** A device that provides protection and temperature control for a newborn infant or a high risk infant of any age.

**indication:** The circumstances in which a drug or other treatment is of value in the care of a patient.

**indirect contact:** A means of transmitting a communicable disease through the use of a vector, a third item that acts a mediary.

**indwelling catheter:** A hollow tube that has been inserted into the lumen of a vessel, or in a hollow organ, for the purpose of transferring some liquid either into or out of that structure.

**infarction:** The death (necrosis) of a localized area of tissue by cutting off its blood supply.

**infect:** To contaminate an organism with a disease-inducing substance.

**infection:** An invasion of a body by disease-producing organisms.

**infectious:** Capable of being transmitted by infection.

**inferior:** Anatomically, situated below, or directed downward, or the lower surface or part of a structure.

**inferior vena cava:** One of the two largest veins in the body that empties venous blood into the right atrium receiving blood from the lower extremities and abdominal organs.

**infiltration:** Leakage of fluid into the interstitial compartment, usually as a result of improper cannulation of a vein, or by design, to render insensitive the area of surgical procedures, such as suturing.

**inflammation:** A tissue reaction to disease, irritation, or infection, characterized by pain, heat, redness, and swelling.

**infusion:** Induction by gravity of a therapeutic fluid other than blood into a vein.

**ingestant:** That which is taken by mouth, ingested.

**ingestion:** Intaking of food or other substances through the mouth.

**inguinal:** Pertaining to the groin.

**inhalation:** The drawing of air or other substances into the lungs.

**injection:** The forcing of a liquid through a needle or other tube into subcutaneous tissues, the blood vessel, a muscle mass, or an organ.

**innervation:** Nerve supply to an area; distribution of the nerves.

**innocuous:** Not harmful.

**innominate:** Not named; having no name.

**innominate artery:** The brachiocephalic artery; arising at the aortic arch; it supplies head and arm on the right side, dividing into the right subclavian and right common carotid arteries.

**innominate bone:** One of two bones forming the pelvic girdle; made up of the fusion of the ilium, ischium, and pubis.

**inotropic:** Tending to increase the force of cardiac contraction.

**insertion:** The point at which a muscle is attached to the bone or fascia that it moves.

**inspection:** A careful visual examination of the patient, for the purpose of identifying any abnormality.

**inspiration:** Inhalation.

**insufficiency:** The condition of being inadequate.

**insufflate:** To blow a powder, vapor, or gas into a cavity.

**insulation:** A nonconducting substance that offers a barrier to the passage of heat or electricity.

**insulin:** A hormone secreted by the islets of Langerhans in the pancreas; essential for the proper metabolism of blood sugar.

**insulin shock:** Not a true form of shock; hypoglycemia caused by excessive insulin dosage, characterized by sweating, tremor, anxiety, unusual behavior, vertigo, and diplopia; may cause death of brain cells.

**integument:** A covering or sheath; the skin.

**intercostal:** Between the ribs.

**intercostal muscles:** Muscles between the ribs.

**intercostal space (ICS):** The space between the ribs; identified by the number of the rib above that space, e.g., the first intercostal space is the space below the first rib, directly above the second rib.

**intermittent positive pressure ventilation:** Assisted or controlled ventilation; most often supplied by bag-valve-mask or by demand valve; mouth-to-mouth ventilation.

**internodal conduction pathways:** The cardiac conduction system in the atria; characterized by specialized conductive tissue paths from the SA node to the left atrium and through both atrial musculature, terminating at the AV junction.

**internuncial neuron:** The neurons that serve to connect nerve cells and centers.

**interstitial fluid:** The fluid bathing the cells; part of the extracellular fluid; continuous with the lympathic fluid.

**intertrochanteric area:** The area between the greater and lesser trochanters of the femur.

**interventricular septum:** The membranous-muscular wall dividing the right and left ventricles of the heart.

**intervertebral disc:** The pad of fibrocartilage between the bodies of adjacent vertebrae.

**intestine:** The portion of the alimentary canal extending from the pylorus to the anus.

- **large intestine:** The portion of the digestive tube extending from the ileocecal valve to the anus; composed of cecum, colon, and rectum; the large bowel.
- **small intestine:** The portion of the digestive tube between the stomach and the cecum; composed of the duodenum, the jejunum, and the ileum; the small bowel.

**intima:** The tunica intima, the innermost layer of tissue forming the wall of an artery, capillary, or vein.

**intoxicate:** To poison; commonly, to cause diminished mental control by means of drugs, alcohol.

**intracardiac injection:** An injection of medication directly into the heart chamber through the thoracic and ventricular walls.

**intracellular fluid:** The portion of total body water contained within the cells.

**intracerebral:** Within the cerebrum.

**intracerebral hematoma:** An extravasation of blood within the brain.

**intracranial:** Within the skull.

**intramuscular:** Within the muscle.

**intravascular fluid:** The portion of the total body water contained within the blood vessels.

**intravenous:** Within or into a vein.

**intravenous fluid:** Sterile water containing additives such as electrolytes and/or sugar in various combinations and concentrations for the purpose of administering to patients per venous infusion.

**intrinsic:** Of internal organs; innate.

**intubation:** An insertion of a tube into an organ that is connected to the outside of the body by means of a hollow tube; commonly, the insertion of a tube into the trachea or esophagus.

**intussusception:** A slipping of a segment of intestine into an adjacent segment.

**inversion:** A turning inward, inside out, or upside down or other reversal of the normal relation of a part.

**involuntary action:** An act performed independent of the will; not voluntary.

**involuntary commitment:** The commitment of a patient to a hospital for treatment or observation against the patient's will.

**involuntary muscle:** The muscles that act without voluntary control; smooth muscle.

**ion:** An atom or group of atoms carrying a positive (cation) or negative (anion) charge of electricity.

**ionization:** Dissociation of matter into ions; such as salt, when added to water, breaks down into sodium (Na) and chlorine (Cl) ions.

**ionization chamber:** A chamber for detecting the ionization of an enclosed gas; used for determining the intensity of ionizing radiation.

**ionizing radiation:** Any radiation resulting when a stable, neutral atom is disrupted, releasing individual ions that bear either positive or negative charges.

**ipecac syrup:** A medication used to induce vomiting.

**IPPV:** Abbreviation for intermittent positive pressure ventilation.

**iris:** The colored portion of the eye that surrounds the pupil.

**irritation:** The act of stimulating; undue sensitivity; slight or temporary disruption of tissues.

**ischemia:** A reduced blood flow into a portion of tissue due to narrowing or occlusion of the artery for that area, thereby producing tissue anoxia.

**ischial tuberosity:** A protuberance on the inferior surface of the ischium lateral to the anus and bearing weight when the person is seated.

**ischium:** Either of the two lowermost portions of the innominate bone.

**islets of Langerhans:** The cluster of cells in the pancreas that produce insulin.

**isoelectric line:** The baseline of an EKG.

**isoproterenol:** A drug that stimulates the beta receptors of the body; beta adrenergic, trade name: Isuprel.

**isosorbide:** A drug of the nitrate family (isosorbide dinitrate) that acts as a vasodilator; used for angina pectoris; trade name: Isordil.

**isotonic:** Having the same osmotic pressure as a reference solution; usually the intracellular fluid, or the red blood cell.

**-itis:** A suffix meaning inflammation.

**IV:** Abbreviation for intravenous.

## J

**jaundice:** The presence of excessive bile pigments in the blood stream that give the skin, mucous membranes, and eyes a distinct yellow color.

**jaw thrust maneuver:** A procedure for opening the airway, wherein the jaw is lifted and pulled forward to keep the tongue from falling back into the airway.

**jejunum:** The second portion of the small intestine, between the duodenum and ileum.

**joint:** The point at which two or more bones articulate; commonly, portion of marijuana.

**joint capsule:** A fibrous sac that, with its synovial lining, encloses a joint.

**jugular:** Pertaining to the neck; large vein on either side of the neck, draining the head via its portion named external jugular, or draining the brain via the internal jugular.

**jump kit:** A closed container fitted with necessary portable equipment and supplies to be used in the emergency care of patients who are treated away from the ambulance.

**junctional rhythm:** An arrhythmia arising from ectopic foci located in the atrioventricular (AV) junction, characterized by absence of positive P wave, short P-R (far point of visual accommodation) interval, and a rate in the range of 40 to 60 beats per minute.

**juxta-:** Prefix meaning near; close to; as in juxtaposition.

## K

**$K^+$:** The chemical symbol for potassium ion.

**kalemia:** The presence of potassium (K) in the blood; potassium is normally present in the blood.

**kaliuresis:** Abnormal excretion of potassium in the urine.

**keep open rate:** A very slow rate of IV infusion designed to keep the route open and not permit the line to clot; a rate of 25 milliliters per hour (American Heart Association.)

**keratin:** The horny proteinlike substance in the upper layers of the skin that is also the principal constituent of the hair and nails.

**keratinize:** To become cornified.

**kernicterus:** A condition with severe neural symptoms, associated with high levels of bilirubin in the blood.

**ketoacidosis:** A condition arising in diabetics where their insulin dose is insufficient to their needs; fat is metabolized, instead of sugar, to ketones; characterized by excessive thirst, urination, vomiting, and hyperventilation of the Kussmaul type.

**ketone:** A compound that is organic and derived by oxidation from a secondary alcohol; produced by metabolism without sugar.

**keying:** Activating a transmitter.

**kidneys:** The paired organs located in the retroperitoneal cavities that filter blood and produce urine; also act as adjuncts to keep a proper acid-base balance.

**kilogram:** A unit of measurement in the metric system, equal to 1,000 grams or 2.2. pounds.

**kilohertz (kHz):** A unit equaling 1,000 Hertz; indicates frequencies of 1,000 cycles per second.

**Kimmelstiel-Wilson syndrome:** intercapillary glomerulosclerosis; kidney failure.

**knee:** A hinge joint between the femur and the tibia.

**KVO:** Abbreviation for keep open, or keep vein open, a slow drip rate.

**Kussmaul's respiration:** A deep, rapid respiration characteristic of hyperglycemia, or diabetic coma, caused by acidosis and the necessity of the body to blow off carbon dioxide as a compensatory mechanism.

## L

**labia:** The lips; the folds of skin and mucous membranes that comprise the vulva.

**labor:** The muscular contractions of the uterus designed to expel the fetus from the mother.

**lacerate:** To tear or cut roughly.

**laceration:** A wound made by tearing or cutting of body tissues.

**lacrimal system:** The system that produces and secretes tears; includes the lacrimal gland and its excretory ducts, lacrimal canaliculi, the lacrimal sac, and the nasolacrimal duct.

- **lacrimal duct:** A short canal that leads from each lower eyelid to the nose, conducting tears into the lacrimal sac (the upper dilated portion of the nasolacrimal duct): also called lacrimal canaliculi.
- **lacrimal gland:** A small gland located in the upper outer angle of the orbit that secretes the tears.
- **lacrimal punctum:** The small mound at the inner angle of each lower lid containing the upper opening of the lacrimal duct.

**lactated Ringer's solution:** A frequently used sterile intravenous solution containing sodium, potassium, calcium, and chloride ions in approximately isotonic concentrations; lactate is added as a buffer for acidotic conditions.

**lactation:** The period when the baby is nourished at the breast; the secretion of milk.

**lactic acid:** An organic acid normally present in tissue and produced in carbohydrate matter by bacterial fermentation; one of the acids produced by anaerobic metabolism, contributing to the acidosis produced in cardiac arrest.

**lactic acidosis:** An excessive amount of lactic acid in the blood causing a low blood pH.

**ladder splint:** A flexible splint consisting of two stout parallel wires and finer crosswires; resembles a ladder.

**landline:** A telephone line.

**laparotomy:** Incision in the abdominal wall; usually for the purpose of inspection of viscera for abnormalities.

**laryngectomee:** A person who has undergone a total or partial surgical removal of the larynx.

**laryngectomy:** The surgical removal of the larynx.

**laryngoscope:** An instrument used for directly visualizing the larynx and its related structures.

**laryngospasm:** A severe constriction of the vocal cords, often in response to allergy or noxious stimuli.

**laryngotracheobronchitis:** Croup; inflammation of the larynx, trachea, and bronchi.

**larynx:** The organ of voice production.

**laser:** A device that produces a beam of coherent, monochromatic visible light.

**lateral:** Of or toward the side; away from the midline of the body.

**lateral malleolus:** The rounded projection on the lateral side of the ankle joint.

**lavage:** A washing-out of a hollow organ, such as the stomach.

**lead:** A recording on electrocardiogram that reflects the flow of electrical current produced by the heart's depolarization from a certain position of the body.

**left heart:** Comprised of the left atrium and left ventricle.

**left heart failure:** Failure of the left ventricle to effectively pump blood, causing excessive backup of blood into the lungs as well as causing poor perfusion of brain, kidneys, and other parts of the body; pump failure; cardiogenic shock may be the outcome.

**leg:** The lower limb generally, specifically, that part of the lower limb extending from the knee to the ankle.

**lens:** The portion of the eye that focuses light rays onto the retina.

**lesion:** A distinct area of pathologically altered tissue; an injury or wound.

**lethal:** Fatal.

**lethargy:** A lack of activity; drowsiness; indifference.

**leukemia:** A disease of the blood-forming organs, characterized by proliferation of white blood cells and pathological changes in the bone marrow and other lymphoid tissue; cancer of the blood.

**leukocyte:** White blood cell.

**levator ani:** The muscle that draws the anus upward in defecation and aids in the support of the pelvic floor; the major muscle affording fecal continence.

**levator palpebrae:** The muscle that raises the upper eye lid.

**lidocaine:** A drug used to prevent or terminate life-threatening ventricular dysrhythmias by suppressing ventricular ectopic activity; trade name: Xylocaine.

**life-threatening arrhythmia:** Any arrhythmia that causes compromise of the cardiac output, usually ventricular in origin but may be of atrial origin especially if the rate is either extremely slow or extremely rapid (less than 40 or more than 160 per minute.)

**ligament:** A tough band of fibrous tissue that connects bone to bone or that supports any organ.

**ligate:** To tie or bind with a ligature.

**ligature:** Any substance, such as catgut, cotton, silk, wire, or artificial fabric, used to tie a vessel or strangulate a part.

**limb presentation:** A delivery in which the presenting part of a fetus is an arm or a leg.

**linear fracture:** A fracture running parallel to the long axis of the bone.

**linear skull fracture:** A skull fracture that runs in a straight line.

**lineman's glove:** A rubber-lined leather glove, especially designed not to conduct electricity.

**liniment:** A liquid drug for external use applied by using gentle friction; usually irritating to the tissue and by increasing blood flow in the area, reduces pain and stiffness.

**lipid:** Fat; any one of a group of fats that is insoluble in water but soluble in fat solvents.

**listless:** A condition characterized by a lack of inclination toward exertion.

**liter:** A unit of volume measure of the metric standard; equal to 1000 milliliters and 1.04 quarts.

**litter:** Stretcher.

**live-birth certificate:** A certificate proving that a live birth has occurred, regardless of the length of the pregnancy.

**liver:** The large organ in the right upper quadrant of the abdomen that secretes bile, produces many essential proteins, detoxifies many substances, and stores glycogen.

**loading dose:** A single large dose of a drug that produces the high blood level necessary to achieve the drug's therapeutic effect.

**log roll:** A method for placing a patient on a carrying device, usually a long spineboard or a flat litter; the patient is rolled on his side, then back on the litter.

**lotion:** Any liquid medicinal preparation intended for local application.

**LSD:** Lysergic acid diethylamide; a serotonic antagonist that induces schizophrenic-like states in humans, with hallucinations that are visual rather than auditory; may produce psychosis; used in the treatment of chronic alcoholism and psychotic disorders.

**lumbar:** Refers to the five vertebrae between the thoracic and sacral vertebrae; also to the region of the trunk between the costal margin and brim of the pelvis.

**lumbar spine:** The five vertebrae between the superiorly placed thoracic and inferiorly oriented sacral vertebrae.

**lumbosacral plexus:** The network of nerves formed by the union of the anterior primary division of the lumbar, sacral, and coccygeal nerves.

**lumen:** The cavity or channel within a tube.

**lungs:** The paired organs in the thorax that effect ventilation and oxygenation.

**lye:** A solution of alkaline salts obtained by the leaching of wood ashes.

**lymph:** A straw colored fluid that circulates in the lymphatic vessels and interstitial space

**lymph node:** Any one of the round, oval, or bean-shaped bodies located along the course of the lymphatic vessels; producing lymphocytes and acting as filters for lymphatic system; when there is infection present, the lymph nodes in the area swell and are detected more easily in the neck and groin.

**lymphoid tissues:** A three-dimensional network of tissue found in the lymph nodes, spleen, thymus, adenoids, and tonsils that intercept and destroy pathogenic substances.

## M

**Magill forceps:** An instrument, similar to scissors, but without sharp points or blades, to remove foreign objects in the upper airway, must be used with a laryngoscope.

**malaise:** A general feeling of vague bodily discomfort.

**malignant:** Cancerous; tending to become progressively worse and resulting in death.

**malingering:** Willful, deliberate, and fraudulent feigning or exaggeration of the symptoms of illness or injury to attain a consciously desired end.

**malleolus:** The large, rounded bony protuberance on either side of the ankle joint.

**malnutrition:** Any disorder of nutrition; usually taken to mean too little nourishment.

**mandible:** The lower jawbone.

**mania:** Disordered mental state of extreme excitement.

**manic-depressive:** Marked by alternating periods of elation and depression.

**manubrium:** The upper portion of the sternum to which the clavicles and first two pairs of ribs are attached.

**marrow cavity:** The central cavity in the shaft of the long bone where yellow marrow is contained.

**MAST:** Abbreviation for medical antishock trousers, or military antishock trousers.

**mastoid:** A portion of the temporal bone that lies behind the ear, contains spongy bone tissue.

**maxilla:** The bone of the face that contains the alveoli of the upper teeth.

**maxillary artery:** The artery on both sides of the face that supplies blood to the face; palpable in front of the ear.

**mean arterial pressure:** The pressure measurement midway between the systolic and diatolic pressures.

**meatus:** a general term for an opening or passage in the body.

**external urethral meatus:** In the male, a slitlike opening of the urethra in the glans penis; in females, the external orifice of the urethra in the vagina.

**meconium:** A dark green mucilaginous substance in the intestine of a full-term fetus, being a mixture of the secretions of the intestinal glands and some amniotic fluid.

**medial:** Toward the midline of the body

**medial malleolus:** The rounded projection on the medial side of the ankle joint.

**median nerve:** A nerve that arises by two roots from the medial and lateral cords of the brachial plexus; controls sensation of the central palm, the thumb, and the first three fingers, as well as the ability to oppose the thumb and the fifth finger.

**mediastinum:** The space within the thorax that contains the heart, pericardium, large blood vessels, vagus nerve, trachea and esophagus; located between the left and right pleural spaces.

**medulla oblongata:** The portion of the brain between the cerebellum and spinal cord that contains the centers for control of respiration, heart beat, and other major control centers.

**megaHertz (mHz):** A unit equaling 1 million Hertz; indicates frequencies of 1 million cycles per second.

**melanin:** The pigment that gives skin its color.

**melena:** The passage of dark stools stained with blood pigment and digested blood; characteristically the stools are black and of a sticky, tarry consistency.

**membrane:** A thin sheet or layer of pliable tissue that serves as a covering or envelope of a part, or the lining of a cavity.

**meninges:** The three membranes covering the spinal cord and brain; the dura mater (external), arachnoid (middle), and pia mater (internal).

**meningitis:** An inflammation of the meninges; characterized by a stiff neck, fever, and delirium.

**menopause:** The point that marks the permanent cessation of menstrual activity.

**menorrhagia:** An excessive flow during a menstrual period.

**menses:** The normal periodic discharge of blood fluid from the uterus; menstruation.

**menstrual flow:** The regular discharge during menses consisting of blood and the shed endometrium (mucous membrane lining of the uterus).

**menstrual period:** The time period of the menstrual flow; usually from 3 to 7 days.

**mescaline:** The most active alkaloid present in the mescal cactus; produces effects similar to those produced by LSD, such as an alteration in mood, changes in perception, visual hallucinations, and an increase in body temperature and blood pressure.

**mesentary:** The tissues by which the intestines are connected to the back surfaces of the abdominal cavity.

**metabolism:** The conversion of food into energy and waste products.

**metacarpal bones:** The five cylindrical bones of the hand extending from the wrist to the fingers.

**metaraminal bitartrate:** A drug that stimulates release of epinephrine and thus stimulates both alpha and beta receptors; increases constriction of the arterioles and venules, but does not significantly increase heart rate.

**metatarsal bones:** The five cylindrical bones of the foot extending from the ankles to the toes.

**meter:** A unit of linear measurement in the metric system; 1 meter equals 1,000 millimeters, equals 39.37 inches.

**Mg:** Chemical symbol for magnesium, cation with double valence ($Mg^{++}$).

**methanol:** Methyl alcohol; wood alcohol; poisonous if ingested, causing extreme metabolic acidosis.

**metric system:** A system of weights and measurements based on decimal units.

**microdrop fluid administration set:** A plastic device used to deliver intravenous fluids and medications at a very slow, accurate rate; approximately 60 drops per milliliter, but may vary among various manufacturers.

**midclavicular line:** An imaginary line beginning in the middle of the clavicle and running parallel to the sternum, passing medially to the male nipple line.

**Mickey:** Short for Mickey Finn; a knockout drug.

**microgram (mcg or μcg):** A unit of weight measurement in the metric system; equal to 0.001 milligrams.

**middle ear:** The tympanic cavity and its ossicles.

**Military Anti-Shock Trousers:** See MAST.

**Military Assistance to Traffic and Safety:** A program using military helicopters and medical corpsmen as supplements to an existing local emergency medical service system to provide emergency assistance to civilian patients.

**milk:** In pharmacology, an aqueous suspension of the insoluble drugs.

**milliampere:** A unit of electrical current, 0.001 ampere.

**milliequivalent (mEg):** A unit of measurement for electrolytes based on a chemical combining power; defined as the weight of a substance present in 1 milliliter of normal solution.

**milligram (mg):** A metric weight measurement, equal to 0.001 gram.

**milliliter (ml):** A metric volume measurement, equal to 0.001 liter.

**millimeter (mm):** A metric linear measurement, equal to 0.001 meter.

**millimeter of mercury (mm Hg):** A metric measurement used in the determination of blood pressure; commonly referred to as torr (Torricelli Unit) when used to designate gas tensions in the blood.

**milliroentgen:** A unit of measure of radiation, equal to 0.001 roentgens.

**millivolt:** A unit of electrical energy, equal to 0.001 volts.

**mineral acid:** A strong acid, such as sulfuric, nitric, or hydrochloric.

**minute volume:** The volume of air inhaled and exhaled during 1 minute; calculated by multiplying tidal volume by respiratory rate.

**miosis:** An abnormal contraction of a pupil.

**miscarriage:** A lay term for the abortion or the premature expulsion of a nonliving fetus from the uterus.

**mitral valve:** A valve located between the left atrium and left ventricle.

**mobile:** A radio designed for installation in, and operation from a vehicle.

**mobile intensive care unit (MICU):** A vehicle designed to provide specialized emergency care for serious conditions (such as cardiac damage or severe trauma).

**Mobitz Type I:** A type of second degree heart block caused by a disturbance in conduction of the stimulus in the upper part of the AV junction; the P-R interval widens progressively in each of the succeeding complexes until the last P wave is not followed by a QRS complex, the cycles repeating; also known as the Wenckebach phenomenon.

**Mobitz Type II:** A type of second degree heart block, usually caused by a disturbance in conduction of the stimulus through the bundle of His or through both bundle branches (trifascicular block): P-R interval does not vary, but every second, third, or fourth P wave is not conducted.

**varying Mobitz II:** Heart block that may have a 1:1 atrial:ventricular conduction, with occasional runs of 2:1, 3:1, etc., conduction; the P-R interval remains constant.

**molestation:** A meddling or interference, often of a sexual nature.

**monitor:** To watch or listen to some transmission; the instrument which enables a person to watch or listen, such as a cardiac monitor.

**monovalent:** Having a single charge, such as sodium ion ($Na^+$).

**morbidity:** A synonym for illness; generally used to refer to an untoward effect of an illness or injury.

**morphine:** A narcotic analgesic used to relieve pain and anxiety; helpful in pulmonary edema because of its peripheral dilating effects.

**mortality:** Refers to death from a given disease or injury; generally thought of as a statistic to state the ratio of death to recovery.

**motion sickness:** A sensation induced by repetitive motion, characterized by nausea and lightheadedness.

**motor nerves:** The nerves that transport messages from the brain to various organs and muscles to stimulate involuntary and voluntary actions.

**mottled:** Characterized by a patchy, discolored appearance.

**mouth gag:** A device for protecting the patient's tongue during a convulsion, or for controlling the tongue during insertion of an artificial airway.

**mouth-to-mouth ventilation:** The preferred emergency method of artificial ventilation when adjuncts are not available.

**mouth-to-nose ventilation:** An emergency method of artificial ventilation when mouth-to-mouth cannot be used.

**mucin:** A mucopolysaccharide or glycoprotein; the chief constituent of mucus.

**mucosa:** Any mucous membrane.

**mucous membrane:** A membrane that lines many organs of the body and contains mucus-secreting glands.

**mucus:** A viscid, slippery secretion that lubricates and protects various body structures.

**multifocal:** Arising from or pertaining to many foci or locations.

**multipara:** A woman who has previously given birth.

**multiplex:** A method by which simultaneous transmission and reception of voice and EKG signals can be achieved over a single frequency.

**murmur:** A sound that may be detected in the heart when one of the valves is leaking or partially closed off.

**muscle:** A tissue composed of elongated cells that have the ability to contract when stimulated, thus causing bone and joints to move, or other anatomical structures to be drawn together.

**muscle avulsion fracture:** A tearing away of a part of bone, usually by a tendon, ligament, or capsule.

**muscle tremor artifact:** The numerous extraneous spikes and waves in the EKG caused by voluntary or involuntary muscle movement or shivering.

**musculature:** The muscular system of the body, or a part of the system.

**musculoskeletal system:** All the collective bones, joints, muscles, and tendons of the body.

**myalgia:** A tenderness or pain in the muscles.

**myasthenia gravis:** A progressive disease of the muscles, characterized by slow paralysis of various muscle groups.

**mydriasis:** A pronounced abnormal dilation of the pupil.

**myocardial:** Pertaining to the musculature of the heart.

**myocardial contusion:** A bruise of the muscular tissue of the heart.

**myocardial infarction:** The damaging or death of an area of heart muscle resulting from a lack of blood supplying the area.

**myocardial rupture:** The breaking apart of a damaged portion of the myocardium, usually several days after the onset of acute myocardial infarction; causes bleeding into the pericardial space, cardiac tamponade, and death if untreated.

**myocardium:** The cardiac muscle.

**myoglobin:** The oxygen-transporting protein of muscle, resembling hemoglobin in function.

**myoglobinuria:** The excretion of myoglobin in the urine, caused by certain instances of crush syndrome or advanced or protracted ischemia of muscle.

## N

**$Na^+$:** The chemical symbol for sodium ion.

**$NaHCO_3$:** The chemical formula for sodium bicarbonate.

**nailbed:** The area of the corium on which the nail rests.

**naloxone:** A narcotic antagonist drug used in the treatment of narcotic overdose; trade name: Narcan.

**narcosis:** An unconscious state produced by narcotics or accumulation of carbon dioxide in the blood, often accompanied by depression of the respiratory system and apnea.

**narcotic:** A drug used to depress the central nervous system, thereby relieving pain and producing sleep.

**nasal bone:** Either of the two small oblong bones that together form the bridge of the nose.

**nasal cannula:** A small tubular prong that fits into the patient's nostril to provide supplemental oxygen; usually there are two, one for each nostril.

**nasolacrimal duct:** The passage leading downward from the lacrimal sac on each side to the inferior meatus of the nose through which tears are conducted into the nasal cavity.

**nasopharyngeal:** Relating to the pharynx at the body of the nose.

**nasopharynx:** The upper part of the pharynx above the level of the palate.

**nausea:** An unpleasant sensation, vaguely referred to the epigastrium and abdomen, often culminating in vomiting.

**nebulizer:** An apparatus for distributing liquid in the form of a fine spray or vapor.

**neck:** The supporting structure of the head, formed by the seven cervical vertebrae, and lying between the head and shoulders.

**necrosis:** A death of an area of tissue, usually caused by the cessation of blood supply.

**necrotic:** Pertaining to dead tissue.

**neonate:** Newborn, up to age of 1 month.

**nerve:** A cordlike structure composed of a collection of fibers that convey impulses between a part of the central nervous system and some other region.

**nerve root:** One of two bundles of nerve fibers emerging from the spinal cord at each vertebra to join and form a spinal nerve.

**nervous system:** The brain, spinal cord, and nerve branches from the central, peripheral, and autonomic systems.

**net, network:** In a communications system, an orderly arrangement of stations interconnected through communications channels and forming a coordinated entity.

**neural:** Relating to any part of the nervous system.

**neural canal:** The canal formed by the vertebrae that houses the spinal cord.

**neural observation sheet:** A chart constructed to provide a convenient record of sequential observations on the neurological status of a patient.

**neurogenic:** Of or originating in the nervous system.

**neurogenic shock:** A shock caused by massive vasodilation and pooling of blood in the peripheral vessels to a degree that adequate perfusion cannot be maintained.

**neurological:** Of or relating to the branch of medical science dealing with the nervous system and its disorders.

**neuron:** A nerve cell.

**neurotic:** A term that refers to a person suffering disorders in thought processes that are not due to demonstrable disease of the central nervous system.

**neurotoxic:** Poisonous to nervous tissue.

**neurotransmitter:** The substance secreted by the axons of nerves to bridge the synapse in order to stimulate the adjoining neuron.

**neutralize:** To render neutral; specifically, the chemical combinations of hydrogen and hydroxyl ions to form water, rendering each ion harmless.

**nitrogen:** An element (N) making up about 80 percent of the atmosphere; present in the tissues of all plants and animals.

**nitrogen narcosis:** A drugged condition created when the nitrogen in the body is exposed to great pressure, as in a deep dive; similar to alcoholic intoxication; the condition can cause divers to remove their breathing equipment while underwater; also called "rapture of the deep."

**nitroglycerin:** A drug used in the treatment of angina pectoris, usually taken under the tongue.

**nocturia:** The necessity to get up at night to urinate.

**nodal:** Usually, pertaining to the AV node.

**noise:** Any extraneous spikes, waves, and complexes in the EKG signal caused by various conditions such as muscle tremor, 60 cycle alternating current interference, improperly attached electrodes, and out of range transmission.

**nonconductor:** Anything that does not transmit an electrical impulse or other source of energy.

**nondirecting question:** An interview technique in which the paramedic asks open-ended questions in an attempt to calm the patient and gather information on the patient's problem.

**norepinephrine:** A hormone and drug used in the treatment of shock primarily for its alpha stimulating properties; causes vasoconstriction; trade name Levophed.

**normal saline:** An intravenous solution containing 0.9 percent sodium chloride in water; used when volume replacement is desired.

**normal sinus rhythm:** The normal rhythm of the heart; in which the rate is between 60–100 beats per minute, the rhythm is regular, the QRS interval is less than .12 seconds, the P–R interval is between .12 and .20 seconds, and there is only one P wave per QRS.

**noxious:** injurious.

**nucleus:** Specifically, the central portion of an atom where most of the mass and all of the positive charges are concentrated; the largest centriole of a cell, containing the genes.

**nystagmus:** Continuous rolling movement of the eyeball.

## O

**obese:** Fat.

**oblique fracture:** A fracture that runs diagonally to the long axis of the bone.

**obstruction:** Blockage.

**occipital:** Pertaining to the back of the head.

**occiput:** The back of the skull.

**occlude:** To close off or stop up; obstruct.

**occlusion:** The act of closure or closing off; an obstruction.

**occlusive dressing:** A watertight dressing for a wound.

**ocular:** Pertaining to the eye.

**oculomotor nerve:** Cranial nerve number three; carries impulses to cause the pupil to react to light by constricting; cerebral edema presses this nerve against the tentorium causing it to cease functioning, thus indicating the "blown pupil."

**odontoid process:** The toothlike structure projecting from the second cervical vertebra.

**ointment:** A semisolid preparation for external application to the body usually containing a medicinal substance.

**olecranon process:** The part of the ulna that fits into the humerus to make the hinge joint of the elbow; the superior tip of the ulna.

**olfactory nerve:** Cranial nerve number one; the nerve that transmits smell impulses to the brain; passes through the cribiform plate of the ethmoid bone.

**oliguria:** Secretion of a diminished amount of urine in relation to the fluid intake.

**oophorectomy:** Surgical removal of the ovaries; usually done in conjunction with a hysterectomy.

**open fracture or dislocation:** A fracture or dislocation exposed to the exterior; an open wound lies over the fracture or dislocation.

**open pneumothorax:** A pneumothorax caused by an opening in the chest wall; a sucking chest wound.

**open wound:** A wound in which the affected tissues are exposed by an external opening.

**opiate:** Technically, one of several alkaloids derived from the opium poppy plant.

**opisthotonos:** A convulsive, rigid arching of the back that is seen in tetanus, severe meningitis, epilepsy, strychnine poisoning, and hysteria.

**optic nerve:** Cranialnerve number two; the nerve that transmits visual impulses from the eye to the brain.

**oral:** Pertaining to the mouth.

**orbits:** The bony, pyramid-shaped cavities in the skull that hold the eyeballs.

**organic chemical:** *A substance obtained by a chemical* process, prepared for use in chemical manufacture or for producing a chemical effect.

**organic compound:** A compound composed of atoms held together by shared electron bonds; an acid made up of molecules containing organic radicals.

**organism:** Any living thing.

**orifice:** The entrance to, or outlet of any body cavity.

**oropharyngeal airway:** The respiratory adjunct placed in the patient's upper airway so that the distal part lies behind the base of the tongue and holds the tongue forward, preventing occlusion of the airway.

**oropharynx:** The area behind the base of the tongue that lies between the soft palate and upper portion of the epiglottis.

**orthopnea:** A severe shortness of breathing or difficulty in breathing when lying down; relieved by placing the patient in a sitting position.

**oscilloscope:** A display device with a screen for viewing an EKG or other physiologic data.

**osmolality:** The concentration of the solute in a solution per unit of solvent.

**osmosis:** The passage of pure solvent from a solution of lower solute concentration to one of higher solute concentration across a semipermeable membrane.

**osmotic pressure:** The pressure exerted by a solution of greater solute concentration upon water in a solution of lower solute concentration.

**ossicle:** A small bone; specifically, one of the three bones of the middle ear, malleus, incas, or stapes.

**-otomy:** A suffix meaning surgical incision into an organ, as in tracheotomy.

**ovary:** The female gonad in which eggs and female hormones are produced.

**overhydration:** A condition that results from excessive retention of fluids; circulatory overload.

**overreaction:** Overly intense reaction or response to a stimulus.

**ovum:** Egg.

**oxygen:** A colorless, odorless, tasteless gas essential to life and comprising 21 percent of the atmosphere; chemical formula: $O_2$.

**oxygen drive:** The stimulus to breathe when the arterial level of oxygen in the blood is low.

**oxygen mask:** A device that fits over a patient's nose and mouth to permit breathing of oxygen which is fed into it.

**oxygen toxicity:** An unusual condition caused by excessive concentration of oxygen in inspired air, resulting in damage to lung tissue; IT IS VERY SELDOM SEEN IN EMERGENCY WORK.

**oxytocin:** A drug used to promote uterine contractions; trade name: Pitocin.

## P

**p:** Abbreviation for post, meaning after.

**PAC:** Abbreviation for premature atrial contraction.

**pacemaker:** The specialized tissue within the heart that initiates stimuli; also an artificial device used to stimulate the heart to beat when the electrical conduction system of the heart is malfunctioning.

**pacemaker site:** The site of origin of the excitation impulse in the SA node or an ectopic focus in any of the electrical conduction system of the heart.

**pager:** A pocket-sized radio receiver that provides one-way communication; used to locate or inform individuals within a limited area.

**palate:** The roof of the mouth.

**pallor:** A paleness of the skin.

**palpate:** To examine by feeling and pressing with the palms and the fingers.

**palpation:** The act of palpating; the act of feeling with the hands for the purpose of determining the consistency of the part beneath.

**palpitation:** A sensation felt under the left breast when the heart "skips a beat" caused by premature ventricular contractions.

**palsy:** A paralysis.

**pancreas:** An intra-abdominal gland that secretes insulin and important digestive juices.

**pancreatitis:** An inflammation of the pancreas.

**papillary muscle:** The muscular protrusions of the myocardium into the ventricular cavities to which the chorae tendineae are attached; purpose is to hold the mitral and tricuspid valves in place (closed) while the ventricles contract.

**papule:** A small, circumscribed, solid elevation of the skin.

**paracentesis:** A draining of fluid from the abdominal cavity by means of a needle or catheter introduced into the cavity through the abdominal wall.

**paradoxical movement:** The motion of an injured section of a flail chest; opposite to the normal movement of the chest wall.

**paralysis:** Loss or impairment of motor function of a part due to a lesion of the neural or muscular mechanism.

**paranoia:** A mental disorder characterized by abnormal suspicions or other delusions, often of persecution or grandeur.

**paraplegia:** The loss of both sensation and motion in the legs and lower parts of the body; most commonly due to damage of the spinal cord.

**parasite:** An animal or vegetable organism that lives on or in another organism.

**parasympathetic nervous system:** A subdivision of the autonomic nervous system involved in control of the involuntary functions; restores the body to normality after stimulus.

**parasympatholytic:** A term used to describe any agent that blocks the effects of stimulation of the parasympathetic system.

**parasympathomimetic:** A term used to describe any agent that mimicks the effects of stimulation of the parasympathetic nervous system.

**parenchyma:** The essential or specialized part of an organ as distinguished from its supporting connective tissue.

**parenteral:** The administration of a medication or fluid by a means other than the digestive tract; intramuscularly or intravenously.

**paresis:** Incomplete or partial paralysis.

**paresthesia:** An abnormal skin sensation, often of the pins-and-needles variety, indicating a disturbance in nerve function.

**parietal area:** Pertaining to or forming any wall of a cavity.

**parietal lobe:** The upper control lobe of the cerebrum; pertaining to or located near the parietal bone of the skull.

**parietal pleura:** A serous membrane that lines the inside of the chest wall and the pericardium.

**paroxysm:** A spasm; a sudden, intense periodic attack, or recurrence of symptoms.

**paroxysmal atrial tachycardia (PAT):** A sudden onset of tachycardia which originates in the atrial conduction system, ending abruptly through some stimulation of the parasympathetic system.

**paroxysmal nocturnal dyspnea (PND):** A severe shortness of breath that occurs at night after several hours of recumbency and forces the patient to sit upright to breathe; caused by left heart failure.

**parturition:** The act of giving birth.

**patch:** A connection of a telephone line or circuit that serves several parties or locations.

**patella:** A small, flat bone that protects the knee joint; the kneecap.

**patent:** Open; unobstructed; obvious.

**pathogenic:** Capable of causing a disease process.

**pathognomonic:** A sign or symptoms that is sufficiently characteristic of a disease process as to make possible a diagnosis on the basis of that finding alone.

**pathologic:** Indicative of or caused by disease.

**pathological fracture:** A fracture in which a specific weakness or destruction of the bone, caused by a certain process, such as cancer, is the reason for the break.

**pathophysiology:** The study of the changes in normal body function in the presence of disease.

**p.c.:** Post cibum, after meals.

**pediatrics:** The medical specialty devoted to the diagnosis and treatment of diseases of children.

**pelvic cavity:** The lowermost portion of the abdominal cavity containing the rectum, urinary bladder, and, in the female, the internal sex organs.

**pelvic girdle:** The large, bony structure supporting the abdominal and pelvic organs; made up of two ossa innominata.

**pelvis:** See pelvic girdle.

**penetrate:** To pierce; the pass into the deeper tissues or into a cavity.

**penis:** The male organ of urinary discharge and copulation.

**Penrose drain:** A surgical instrument made by drawing a strip of gauze through a tube of thin rubber; also the tube of thin rubber itself; sometimes the latter is used as a tourniquet.

**peptic ulcer:** An ulcer produced by the action of acid, pepsin, gastric juice in the stomach, lower esophagus, and proximal duodenum.

**percussion:** The act of tapping a part of the body; used as an aid in diagnosing the condition of the underlying body structures by the sound obtained by tapping with the fingers.

**percutaneous:** Through the skin.

**perfusion:** The act of pouring through or into; the blood getting to the cells in order to exchange gases, nutrients, etc., with the cells.

**pericardial cavity:** The space or sac formed by the two layers of the pericardium, the outer parietal pericardium, and the inner visceral pericardium.

**pericardial fluid:** The small amount of fluid secreted by the inner, serous, visceral pericardium.

**pericardial effusion:** The fluid within the pericardial sac.

**pericardial tamponade:** The accumulation of excess fluid or blood in the pericardial sac; interferes with heart action.

**pericardium:** The double-layered sac holding the heart and the origins of the superior vena cava and pulmonary artery.

**perineum:** The region between the genitals and the anus.

**periosteum:** The dense, fibrous tissue covering the bone.

**peripheral:** Pertaining to the outside; that which is situated away from the center part.

**peripheral nervous system:** The portion of the nervous system consisting of the nerves and ganglia outside the brain and the spinal column.

**peripheral vascular resistance:** The resistance to blood flow in the systemic circulation; depends on the degree of constriction or dilation of the small arteries, arterioles, venules, and veins making up the peripheral vascular system.

**peripheral vasoconstriction:** The constriction of blood vessels causing an increase in blood pressure.

**peripheral vasodilation:** The dilation of blood vessels causing a decrease in blood pressure.

**peristalsis:** The successive waves of muscular contraction and relaxation proceeding uniformly along a hollow tube, such as the esophagus or intestine; this motion propels the contents of the tube forward.

**peritoneal cavity:** The abdominal cavity.

**peritoneum:** The serous membrane lining the abdominal cavity.

**peritonitis:** An inflammation of the peritoneum.

**petechia:** A minute red spot due to escape of a small amount of blood within the skin.

**petit mal seizure:** A type of epileptic attack, characterized by a momentary loss of awareness but not accompanied by loss of motor tone.

**pH:** A symbol used to indicate the acidity or alkalinity of a substance; the negative log of the concentration of hydrogen ions in a substance.

**-phagia:** Suffix meaning to swallow, to eat, to ingest.

**phalanx:** Any bone of the finger or toe.

**pharmacology:** The study of drugs and their origin, nature, properties, and effects.

**pharyngeal:** Pertaining to the pharynx.

**pharynx:** The portion of the airway between the nasal cavity and the larynx.

**phenobarbital:** One of the barbiturates; a hypnotic-sedative.

**phenylephrine:** A pure alpha-adrenergic agent used as a vasoconstrictor; trade name: Neosynephrine.

**phlebitis:** An inflammation of the wall of a vein manifested by tenderness, redness, and a slight edema along part of the length of the vein.

**phobia:** An abnormal and persistent fear of a specific object or situation.

**-phonia:** Suffix or prefix having to do with speech or sounds.

**phrenic nerve:** The motor nerve of the diaphragm.

**physical dependence:** Habituation or use of a drug, or other maneuver, because of its physiologic support, and because of the undesirable effects of withdrawal.

**physiologic action:** The action caused by a drug when given in the concentrations normally present in the body; applies only to drugs that are derived from normal body chemicals.

**physiology:** The study of body functions.

**pia mater:** The innermost and most delicate of the three membranes covering the brain and spinal cord.

**PID:** Abbreviation for pelvic inflammatory disease.

**piggyback:** Used to describe the process of adding another solution to an infusion set by inserting a needle connected to a second infusion set into the first set.

**pigment:** A coloring matter of dyestuff.

**pill:** A small ball or oval that has been molded or compressed from a powdered drug; often coated to disguise an unpleasant taste, or to delay absorption.

**pin index:** A safety attachment on the outlet valve of a gas-filled cylinder.

**pinna:** The outer portion of the ear that leads to the ear canal.

**pitting edema:** A severe edema of the extremities in which pressure on the tissue with the fingers causes an indentation that persists after release of pressure.

**pituitary gland:** The master gland of the body, located in the brain behind the eyes; influences the secretion of all other glands.

**placebo:** An inactive substance resembling a medication that may be given experimentally or for its psychologic effects.

**placenta:** A vascular organ attached to the uterine wall that supplies oxygen and nutrients to the fetus; also called the afterbirth.

**placenta previa:** A delivery in which the placenta is the presenting part; may result in exsanguinating hemorrhage.

**plantar:** Refers to the sole of the foot.

**plasma:** The fluid portion of the blood, retains the clotting factors, but has no red or white cells.

**platelet:** A small cellular element in the blood that assists in blood clotting.

**pleura:** A continuous serous membrane that lines the outer surfaces of the lungs and the internal surface of the thoracic cavity.

**pleural cavity:** The potential space between the parietal and visceral pleura.

**pleural effusion:** An excessive accumulation of fluid in the pleural cavity.

**pleuritic pain:** A sharp chest pain that is made worse by deep breathing, coughing, or laughing; characteristic of pleuritis.

**pleuritis:** Inflammation of the pleura.

**plexus:** A network or tangle of nerves, blood, or lymphatic vessels.

**brachial plexus:** A network of nerves containing the motor and sensory innervation of the arm.

**lumbosacral plexus:** A network of nerves containing the motor and sensory innervation of the leg.

**PND:** Abbreviation for paroxysmal nocturnal dyspnea.

**-pnea:** Suffix for respiration, breathing.

**pneumo-:** Prefix for air or gas; lung.

**pneumonia:** An acute infectious disease of the lungs; causes an effusion.

**pneumothorax:** An accumulation of air in the pleural cavity, usually entering after a wound or injury that causes a penetration of the chest wall or laceration of the lung.

**p.o.:** Abbreviation for *per os,* by mouth.

**point of maximal impulse (PMI):** A palpable thrust of the apex of the heart against the thoracic cage during ventricular contraction; normally palpated in the fifth left intercostal space in the midclavicular line.

**point tenderness:** An area of tenderness limited to 2 or 3 centimeters in diameter; point tenderness can be located in any area of the body; usually associated with acute inflammation, as in peritonitis (abdominal point tenderness.)

**poly-:** Prefix meaning many or much.

**polydacron rope:** A specially designed rope made from nonconductive plastic (polydacron) material; used to manipulate live electric wires.

**polydipsia:** A condition of excessive thirst.

**polyphagia:** A condition of excessive hunger.

**polyuria:** A condition of excessive urination.

**popliteal:** The area or space behind the knee joint.

**popliteal artery:** The continuation of the femoral artery in the area behind the knee joint; used to auscultate pulse when taking a femoral blood pressure.

**posterior:** Situated in the back of or behind a surface.

**posterior tibial artery:** The artery located posterior to the medial malleolus, supplies blood to the foot.

**postictal:** Refers to the period after the convulsive stage of a seizure.

**postmortem:** After death; commonly, the detailed examination of a body after death, to determine the cause of death.

**postpartum:** After childbirth.

**potassium:** A mineral substance necessary for the proper functioning of the heart and other tissues.

**potentiation:** The enhancement of the effect of one drug by another.

**powder:** A drug that has been ground into powder form.

**P-QRS-T:** One heartbeat on EKG, representing the atrial depolariziation (P), ventricular depolarization (QRS), and ventricular repolarization (T).

**precordial:** A term that refers to the general area overlying the heart and lower thorax.

**precordial thump:** A sharp blow delivered to the midsternum for the purpose of terminating ventricular tachycardia or stimulating the heart to beat in systole. No longer recognized by the American Heart Association as an effective maneuver.

**precursor:** Something in a stage of a process that precedes a later stage.

**pre-eclampsia:** The condition that precedes eclampsia, or toxemia of pregnancy, characterized by hypertension, edema, and seizures.

**preinfarction angina:** An unstable angina.

**premature atrial contraction (PAC):** An extra atrial and ventricular contraction with normal QRS complexes; occurring early in the cardiac cycle; caused by excitation impulses arising in single or multiple foci in the internodal pathways.

**premature junctional contraction (PJC):** Also called premature nodal contractions (PNC) extra ventricular contractions with normal or abnormal QRS complexes arising in single or multiple ectopic foci in the AV junction.

**prenatal:** Before birth.

**presenting part:** The part of the baby that emerges first during delivery.

**pressure-compensated flow meter:** An instrument designed to measure the rate of gas flow from a compressed gas cylinder.

**pressure dressing:** A dressing with which enough pressure is applied over a wound site to stop bleeding.

**pressure point:** One of several places on the body where the blood flow of a given artery can be restricted by pressing the artery against an underlying bone.

**pressure splints:** An inflatable plastic circumferential splint that can be applied to an extremity and inflated to achieve stability after a fracture.

**priapism:** A persistent erection of the penis, especially when due to disease, injury, or excessive quantities of androgens.

**primipara:** A woman who is about to give birth to a baby for the first time.

**P-R interval (PRI):** The period of time between the beginning of the atrial depolarization and the beginning of the ventricular depolarization, signifying the time of conduction of a stimulus.

**prn:** Abbreviation for *pro re nata;* as needed.

**procainamide:** A drug used to prevent or terminate either atrial or ventricular arrhythmias; trade name: Pronestyl.

**prognosis:** A probable outcome of a disease based on assumptive knowledge.

**prolapse:** To fall out or slip down; usually refers to an organ or other body part.

**prolapsed cord:** A delivery in which the umbilical cord appears at the vaginal opening before the head of the infant.

**pronation:** The act of assuming the prone position; placing or lying face downward; turning the hand palm down.

**prone:** A position of lying face down.

**prophylaxis:** A method for taking measure to prevent the occurrence of a given disease or abnormal state.

**propranolol:** A drug used to prevent or terminate life-threatening arrhythmias; also used to reduce tachycardias, to suppress the beta receptors of the sympathetic system; trade name: Inderal.

**prostate:** A gland at the base of the male bladder that often becomes enlarged later in life and causes an obstruction of urine flow.

**prosthesis:** An artificial part made to replace a natural one.

**prostration:** A collapse.

**proteinuria:** Protein in the urine.

**protoplasm:** A viscid, transparent, colloid material, the essential constituent of the living cell.

**proximal:** Closer to any point of reference usually refers to closeness to the midline of the body.

**pruritis:** An itching condition.

**pry bar:** An extrication tool used for prying.

**psilocybin:** A hallucinogenic agent obtained from the mushroom *Psilocybe mexicana.*

**psychiatry:** The medical study dealing with mental disorders.

**psychogenic shock:** A fainting spell as a result of transient generalized cerebral ischemia; not a true shock condition.

**psychological dependence:** Dependence of a drug, or other therapeutic maneuvers, because of its support to the patient's psyche, rather than to his physiologic function.

**psychosis:** A mental disorder characterized by a disintegration of personality and loss of contact with reality.

**psychosomatic:** An indication of an illness in which some part of the cause is related to emotional factors.

**pubic symphysis:** The joint formed by union of the bodies of the pubic bones in the midsagittal plane, characterized by a thick mass of fibrocartilage.

**puerperium:** The convalescent period following the birth of a baby.

**pulmonary:** Pertaining to the lungs or related structures.

**pulmonary alveoli:** The air sacs of the lungs.

**pulmonary artery:** The major artery leading from the right ventricle to the lungs.

**pulmonary circulation:** The passage of blood from the right ventricle through the pulmonary artery and all of its branches and capillaries in the lungs, and then back to the left atrium through the pulmonary veins.

**pulmonary contusion:** A bruise of the pulmonary tissue.

**pulmonary edema:** The condition of the lungs when the pulmonary alveoli are filled with exudate and foam, usually secondary to left heart failure.

**pulmonary embolism:** Obstruction of the pulmonary arteries by emboli of any foreign material in the venous system.

**pulmonary resuscitation:** A technique providing artificial ventilation, through mouth to mouth, mouth to nose, or using any of the airway adjuncts.

**pulmonary valve:** The valve between the right ventricle and the pulmonary artery.

**pulmonary veins:** The veins that carry oxygenated blood from the lungs to the left atrium.

**pulsatile:** A term that refers to a pulsating or throbbing action.

**pulse:** The rhythmic expansion and contraction of an arterial wall caused by ventricular systole and diastole.

**pulse deficit:** The difference in heart rate between apical rate and the rate obtained by palpating a peripheral artery.

**pulse pressure:** The difference between the systolic and diastolic pressures.

**pulse rate:** The heart rate determined by counting the number of pulsations occurring in any superficial artery.

**pump failure:** A partial or total failure of the heart to pump blood effectively; causes cardiogenic shock.

**punctum lacrimale:** The orifice of the lacrimal duct leading to the nose, situated at the inner angle of the lower eyelid.

**pupil:** The small opening in the center of the iris.

**pupillary:** Pertaining to the pupil.

**Purkinje network:** The portion of the electrical conduction system in the ventricles that conducts the electrical impulses causing depolarization of the myocardium.

**PVC:** Abbreviation for premature ventricular contractions.

**P wave:** The wave on EKG that represents depolarization of the atria.

## Q

**q.d.:** Abbreviation for *quaque die;* every day.

**q.h.:** Abbreviation for *quaque hora;* every hour.

**q. 2 h.:** Abbreviation for *quaque seconda hora;* every 2 hours.

**q.i.d.:** Abbreviation for *quater in die;* four times a day.

**QRS complex:** The deflections of the EKG produced during ventricular depolarizations; Q is the first negative deflection before the first positive deflection; R is the first positive deflection; and S is a negative deflection occurring after the R.

**Q-T interval:** The period between the onset of ventricular depolarization and the end of repolarization of the ventricle; measured from the beginning of the QRS complex to the end of the T wave; the length of time it takes for the ventricles to depolarize and repolarize.

**quadrant:** One of the four quarters of the abdomen.

**quadriplegia:** A paralysis of both arms and legs.

**quinidine:** A drug used to treat various atrial and ventricular arrhythmias.

**Q wave:** The first negative deflection of the QRS complex; not preceded by an R wave.

## R

**raccoon sign:** Bilateral symmetrical periorbital ecchymoses seen with basal skull fractures; also called coon's eyes.

**rad:** A measure of the dose absorbed from ionizing radiation; equivalent to 100 ergs of energy per gram.

**radial:** Pertaining to the radial bone of the arm.

**radial artery:** One of the major arteries of the forearm; the pulse is palpable at the base of the thumb.

**radial nerve:** One of the three major nerves of the arm; descending at the back of the arm closely applied to the humerus and then into the forearm, it is ultimately distributed to the skin at the back of the arm, forearm and hand.

**radiant energy:** Any energy that is radiated from any source.

**radiation:** The process of emitting energy in a particulate or wave form.

**radiation sickness:** The condition that follows excessive irradiation from any source.

**radio patch:** An interconnection between radio and telephone communications circuits.

**radioactivity:** The property of spontaneously emitting rays or subatomic particles of matter accompanied by the release of large amounts of energy.

**radius:** The bone on the thumb side of the forearm.

**rales:** An abnormal breath sound produced by the flow of air through bronchi and bronchioles when they are constricted by spasm or filled by secretions.

**rape:** Sexual intercourse by force.

**rash:** An eruption of the skin, either localized or generalized.

**receptor:** A specialized area in a tissue that initiates a certain action upon specific stimulation.

**recompression:** The repressurization of divers who have been decompressed too soon.

**rectal temperature:** The core body temperature obtained by insertion of a thermometer into the rectum and retaining it for a minute; normally 1 degree Fahrenheit higher than oral temperature.

**rectum:** The distal portion of the large intestine.

**red blood cell:** An erythrocyte; the cell that carries oxygen from alveoli to cell.

**reduce:** To restore a part to its normal position.

**reducing valve:** A device attached to an oxygen container to control the pressure of oxygen delivery to the patient.

**reflex:** An involuntary muscular action in response to stimulation.

**reflex action:** An automatic reaction to a stimulus such as pulling one's hand away from something hot.

**reflex arc:** The nervous root utilized in a reflex action, consisting of an afferent (sensory) nerve, internuncial (connecting) nerve, and an efferent (motor) nerve.

**regression:** In psychiatry, a return to an earlier or former developmental state.

**regurgitation:** A backward flowing, as the casting up of undigested food from the stomach to the mouth.

**relative refractory period:** The period of repolarization of the heart muscle and conduction systems during which another stimulus may cause a premature contraction.

**renal:** Pertaining to the kidney.

**repeater:** A transmitter that picks up a radio signal and rebroadcasts it, thus extending the range of radio communication system.

**repolarization:** The electrical process of recharging depolarized muscle fibers back to the resting state.

**reproductive system:** The body system that includes all the organs necessary for reproduction.

**rescue:** The freeing of persons from threatening or dangerous situations by prompt and vigorous action.

**heavy rescue:** A rescue activity that involves the use of complicated tools, equipment, and procedures.

**light rescue:** A rescue activity using simple means and a minimum of equipment.

**reservoir:** The location where infecting organisms live and multiply.

**respiration:** The act of breathing; the exchange of oxygen and carbon dioxide in the tissues, lungs.

**internal respiration:** The exchange of oxygen and carbon dioxide at the cellular level.

**external respiration:** The exchange of oxygen and carbon dioxide between the alveoli and blood in the lungs.

**respiratory arrest:** The cessation of breathing.

**respiratory failure:** A failure of the respiratory system to maintain an oxygen pressure greater than 60 torr and a carbon dioxide pressure of less than 50 torr.

**respiratory system:** A system of organs that controls the inspiration of oxygen and the expiration of carbon dioxide.

**response time:** The length of time required for the emergency medical services team to arrive at the scene of an emergency after receiving a call for help.

**resting potential:** The electrical charge of the muscle fibers during the resting polarized state.

**resuscitation:** The act of reviving an unconscious patient.

**retention:** The inability to void.

**retina:** The lining of the back of the eye that receives visual images and transmits them via the optic nerve to the brain.

**retractions:** The drawing in of the intercostal muscles above the clavicles; seen in respiratory arrest.

**retransmission:** The use of a radio communications set for rebroadcasting a message on a different frequency simultaneously with the original broadcast by means of an electrically operated linkage device between the receiver and transmitter of the set.

**retro-:** The prefix meaning located behind.

**retrograde amnesia:** An amnesia for events that occurred before a traumatic event or before the disease that caused the condition.

**retroperitoneal:** Pertaining to a location behind the peritoneum.

**retrosternal:** Situated or occurring behind the sternum.

**Rh factor:** An antigen present in the blood cells of some individuals; when present, the individual is said to be Rh positive; when not present, to be Rh negative.

**rhonchi:** Coarse rattling sounds somewhat like snoring, usually caused by secretions in the bronchial tubes.

**rib:** One of the 24 bones forming the thoracic cavity wall.

**rib cage:** The skeletal framework of the chest; composed of the sternum, the ribs, and the thoracic vertebrae.

**right atrium:** The upper chamber of the right heart that is continuous with the venae cavae and channels blood into the right ventricle.

**right heart:** The right atrium and the right ventricle.

**right heart failure:** The failure of the right ventricle to pump blood effectively, causing backup of blood into the systemic veins, with consequent edema of body tissues.

**right ventricle:** The lower right chamber of the heart that receives blood from the right atrium and pumps blood out through the pulmonary valve into the pulmonary artery.

**rigid splint:** A splint made of a firm material that can be applied to an injured extremity to prevent motion at the site of a fracture or dislocation.

**risk factor:** A variable that contributes to the initiation and continuation of a disease process.

**Robinson stretcher:** Split frame stretcher.

**roentgen:** The international unit of x-ray or gamma radiation.

**roller dressing:** A strip of rolled-up material used for dressings.

**R-on-T phenomenon:** An ominous premature ventricular contraction that occurs very near the vulnerable period of the relative refractory period; may produce ventricular fibrillation.

**rotation:** The turning or movement of a body around its axis.

**R–R interval:** The interval of the EKG between the onset of the ventricular depolarization of one complex and the onset of the subsequent ventricular depolarization.

**rupture:** A tear or dissolution of continuity; a break of any organ or tissue.

**R wave:** The initial positive wave or deflection of the QRS complex on EKG.

**Rx:** Abbreviation for recipe; take.

## S

**s:** Abbreviation for *sine;* without.

**sacral:** Pertaining to the sacrum, which is the fused bone of the five sacral vertebrae, part of the pelvic girdle.

**sacral spine:** The five fused vertebrae which make up the sacrum.

**sacroiliac joint:** Left and right joining of the sacrum and ilia.

**sacrum:** The part of the lower spine made up of the five fused sacral vertebrae.

**saddle joint:** A joint formed where a portion of one bone hangs over another, as in the thumb.

**safe residual:** The pressure reading at which an oxygen cylinder should be replaced to avoid totally depleting its contents; the standard safe residual is 100 psi.

**saline:** Containing salt.

**saline solution:** A solution of any salt, but usually refers to a solution of sodium chloride.

**saliva:** The clear, alkaline fluid secreted by the salivary glands.

**salivary glands:** The glands that produce and secrete saliva, connected to the mouth by ducts.

**salivation:** An excess secretion of saliva.

**scab:** A crust formed by the coagulation of blood, pus, serum, or any combination of these on the surface of an ulcer, erosion, abrasion, or any other type of wound.

**scalp vein set:** An intravenous needle and tube set with butterfly wings; used for initiating an IV line in the veins of a child's scalp.

**scapula:** The shoulder blade.

**scapular spine:** The prominent triangular ridge on the dorsal aspect of the scapula.

**sciatic nerve:** A major collection of nerve fibers arising from the lumbosacral plexus and subserving most sensation of the lower extremity and motion of the leg and foot.

**sclera:** The white, opaque, outer layer of the eyeball.

**scrotum:** A pouch of thickened skin hanging at the base of the penis in the midline; contains the testes and their accessory ducts and vessels.

**SCUBA:** Abbreviation for self-contained underwater breathing apparatus.

**seal bark:** A characteristic hoarse, barking cough heard in croup.

**sebaceous gland:** A gland in the dermis that secretes sebum.

**sebum:** The secretion of the sebaceous gland; a thick, oily, semifluid substance composed of fat and epithelial debris from the cells of the skin.

**secondary infection:** An infection occurring in a patient already suffering from a wound or disease.

**second degree burn:** A burn penetrating beneath the superficial skin layers, producing edema and blisters.

**sedative:** A drug that depresses the activity of the central nervous system; has a calming effect.

**seizure:** A sudden attack or recurrence of a disease; a convulsion; an attack of epilepsy.

**selective calling equipment:** An encoding device used to alert or signal a particular pager unit or group of pager units.

**self-contained air mask:** A mask used for delivery of air to a rescuer when entering contaminated areas filled with smoke or poisonous gases; consists of a tight-fitting mask, controls, and an air supply.

**semicircular canals:** The small structures in the inner ear that maintain one's equilibrium.

**semiconscious:** Stuporous; partially conscious.

**seminal duct:** The duct through which sperm pass into the seminal vesicles.

**seminal vesicles:** Either of the paired, sacculated pouches attached to the posterior past of the urinary bladder in the male; the duct of each joins the ductus deferens of the same side to form the ejaculatory duct.

**senile:** Pertaining to old age; implies loss of mental ability.

**sense:** Any one of the faculties by which the conditions or properties of things are perceived.

**sensory nerves:** The nerves that conduct impulses from various sense modalities through the spinal cord to the brain.

**sepsis:** The presence in the blood or other tissues of pathogenic microorganisms or their toxins.

**septum:** A dividing wall or partition, usually separating two cavities.

**sequelae:** Any lesion or affection following or caused by an attack of disease.

**sequestration:** Abnormal separation of a part from a whole.

**serosa:** The outermost layer of most organs, usually continuous with the lining of the body cavities; a thin membrane having the ability to exude plasma in response to injury and to absorb material in solution.

**serum:** The liquid portion of the blood containing all of the dissolved constituents except those used for clotting.

**sesamoid:** A small nodular bone embedded in a tendon or joint capsule.

**shadow area:** A dead spot on a communicating area where radio contact is difficult or impossible to achieve.

**shell temperature:** The temperature of the extremities and surface of the body.

**shivering:** A trembling from cold or fear; produces heat by muscular contractions.

**shock:** A state of inadequate tissue perfusion that may be a result of pump failure (cardiogenic shock), volume loss or sequestration (hypovolemic shock), vasolilation (neurogenic shock), or any combination of these.

**anaphylactic shock:** A rapidly occurring state of collapse caused by hypersensitivity to drugs or other foreign materials (insect venom, certain foods, inhaled allergenic); symptoms may include hives, wheezing, tissue edema, bronchospasm, vascular collapse.

**septic shock:** A shock developing in the presence of, and as a result of, severe infection.

**shoulder girdle:** The encircling bony structure supporting the upper limbs; comprised of the scapulae, clavicles, and their central attachment.

**shoulder joint:** A ball and socket joint between the head of the humerus and the glenoid fossa of the scapula.

**shunt:** A situation in which a portion of the output of the right heart reaches the left heart without being oxygenated in the lungs; may be due to atelectasis, pulmonary edema, or a variety of other factors.

**dialysis shunt:** The surgically produced shunt between the radial artery and cephalic vein between the wrist and elbow of the dialysis patient; used to transfer blood to and from the dialysis machine.

**sickle cell anemia:** A hereditary, genetically determined hemolytic anemia occurring in the black population; characterized by joint pain, acute attacks of abdominal pain, and recurrent embolic episodes.

**SIDS:** Abbreviation for sudden infant death syndrome.

**sigmoid colon:** The terminal division of the large intestine that makes several turns, roughly resembling the letter sigma, and terminates at the rectum.

**sign:** Any objective evidence of physical manifestation of a disease.

**silent acute myocardial infarction:** An acute myocardial infarction not accompanied by pain.

**simple fracture:** A fracture that is not compound; the skin is not broken over the break in the bone.

**simplex:** A radio communications system using only one frequency; voice or telemetry signals can be transmitted or received, but simultaneous transmission and reception is not possible.

**sinoatrial node (SA node):** The physiological pacemaker of the heart; a group of specialized fibers that rhythmically initiate stimuli at the rate of approximately 72 beats per minute that in turn traverse the heart's conduction system to cause the atria and then the ventricles to contract; can develop stimuli at the lower rate of 40 per minute to an upper limit of approximately 160 per minute.

**sinus:** A general term for a hollow space, such as a channel for venous blood in the cranium or an air cavity in one of the facial bones.

**sinus arrhythmias:** An irregularity of the heartbeat caused by interference with impulses from the SA node.

**sinus arrhythmia:** A common and usually innocuous dysrhythmia characterized by an irregular rhythm with an otherwise normal sinus rhythm; cause by breathing rhythms.

**sinus bradycardia:** A sinus rhythm with a heart rate of less than 60 beats per minute.

**sinus tachycardia:** A sinus rhythm with a heart rate of greater than 100 beats per minute.

**six man stretcher pass:** A method of transporting a patient on a litter over rough terrain; consists of passing a stretcher by six persons in two parallel rows, the last two persons in each row moving ahead each time as the stretcher passes them.

**skeletal muscle:** A striated muscle usually attached to, and moving, the bones, sometimes fascia; generally under voluntary control.

**skeleton:** The hard, bony structure that forms the main support of the body.

**skin:** The outer integument or covering of the body, consisting of the dermis and the epidermis; the largest organ of the body; contains various sensory and regulatory mechanisms.

**skull:** The bony structure surrounding the brain; consists of the cranial bones, the facial bones, and the teeth.

**sling:** A triangular bandage applied around the neck to support an injured upper extremity; any wide or narrow material long enough to suspend an upper extremity by passing the material around the neck; used to support and protect an injury of the arm, shoulder, or clavicle.

**sling and swathe:** A bandage in which the arm is placed in a sling and is bound to the body by another bandage placed around the chest and arm to hold the arm close to the body.

**slough:** To cast off tissue, usually necrotic, separating from living tissue.

**small intestine:** The portion of the intestine between the stomach and colon.

**smooth muscle:** A nonstriated muscle found in the walls of the internal organs and blood vessels; generally not under voluntary control.

**sniffing position:** The position for endotracheal intubation with the neck flexed and the head extended.

**snorkel:** A tube housing an air intake; exhaust pipe that can be used for breathing underwater when one end is projected above the water.

**snowblindness:** Obscured vision caused by sunlight reflected off snow.

**socket:** A hollow in a joint or other part into which a corresponding organ or part fits.

**sodium bicarbonate:** A drug with alkaine properties used to raise the pH of the body when acidosis is present; $NaHCO_3$.

**sodium hydroxide:** A caustic soda soluble in water; used externally as a caustic; highly damaging to tissue.

**soft tissue:** The nonbony and noncartilaginous tissue of the body.

**solution:** A liquid consisting of two or more substances that are molecularly dispersed through one another in a homogeneous manner.

**sporific:** Producing deep sleep; usually considered a characteristic of a drug.

**source:** The object, person, or substance from which an infectious agent passes to a host.

**spasm:** A sudden, violent, involuntary contraction of a muscle, or group of muscles, attended by pain and interference with function; a sudden but transitory constriction of a passage, canal, or orifice.

**sphincter:** A muscle that encircles a duct, tube, or opening in such a way that its contraction constricts the opening.

**sphygmomanometer:** A device for measuring blood pressure.

**spinal canal:** The tunnel through which the spinal cord passes.

**spineboard:** A wooden or metal device primarily used for extrication and transportation of patients with actual or suspected spinal injuries.

**spiral fracture:** A fracture in which the line of break runs diagonally around the long axis of the bone.

**spirits:** A preparation of volatile substances dissolved in alcohol.

**spleen:** The largest lymphatic organ of the body; located in the left upper quadrant of the abdomen.

**splenomegaly:** Enlargement of the spleen.

**splint:** Any support used to immobilize a fracture or to restrict movement of a part.

**spontaneous pneumothorax:** A rupture of the lung parenchyma resulting in the accumulation of air in the pleural space without trauma.

**sprain:** A trauma to a joint causing injury to the ligaments.

**sputum:** Expectorated matter, especially mucus or matter resulting from diseases of the air passages.

**squelch:** A system for removing unwanted background noise on a radio frequency.

**S–T segment:** The interval of the EKG between the end of the QRS complex and the beginning of the T wave; often elevated, reflecting current of injury in that part of the heart scanned by the particular lead, or depressed, reflecting ischemia of the same area.

**stat:** Abbreviation for *statim*, immediately.

**status asthmaticus:** A severe, prolonged asthmatic attack that cannot be broken with epinephrine.

**status epilepticus:** The occurrence of two or more seizures without a period of complete consciousness between them.

**stenosis:** The narrowing or stricture of a duct or canal.

**sterile:** Free from living organisms, such as bacteria.

**sterilize:** To render sterile or free from bacterial contamination; to make an organism unable to reproduce.

**sternoclavicular joint:** The articulation of the clavicle, the sternum, and the cartilage of the first rib with an articular disc; subdivides the joint into two cavities.

**sternum:** The long, flat bone located in the midline in the anterior part of the thoracic cage; articulates above with the clavicles and along the sides with the cartilages of the first seven ribs.

**sternocleidomastoid muscle:** The large muscle on either side of the neck that flexes the head.

**stethoscope:** An instrument for performing auscultation.

**stillbirth:** The birth of a dead fetus.

**stimulant:** Any agent that increases the level of bodily activity.

**stoma:** A small opening, especially an artificially created opening.

**stomach:** The hollow digestive organ in the epigastrium that receives food from the esophagus.

**stool:** Feces; the matter discharged at defecation.

**stove-in chest:** See flail chest.

**straddle load:** A method for placing a patient on a long spineboard by straddling both board and patient and sliding the patient on the board.

**strain:** An injury to a muscle caused by a violent contraction or an excessive forceable stretching.

**stress:** Any chemical, physical, or emotional factor that causes mental or bodily tension; may be a cause of disease.

**stretcher:** A carrying device that enables two or more persons to lift and carry a patient who is lying down.

**ambulance stretcher:** A carrying device used to transport patients to, from, or in an ambulance; usually wheeled but also portable.

**army stretcher:** A folding carrying device made of wooden poles and covered with canvas with short, folding legs.

**basket stretcher:** A litter designed for the removal of patients over rough terrain or from heights; consists of an oblong plastic shell with low sides.

**split-frame stretcher:** A litter that can be divided longitudinally, slipped beneath the patient from each side, and locked at each end, providing an extrication as well as a transport device.

**stretcher lash:** A method for securing patients to stretchers so that the patients can be extricated or transported in a variety of positions without injury; patients can be secured with the use of ropes or other straps of material.

**stricture:** The narrowing of a duct or any natural passage by an inflammatory process, trauma, fibrosis, muscular spasm, or pressure from adjacent structures.

**stridor:** A harsh, high-pitched respiratory sound associated with severe upper airway obstruction.

**stroke:** A cerebrovascular accident of sudden onset.

**stroke volume:** The amount of blood pumped forward by the heart each time the ventricles contract.

**stupor:** A state of reduced sensitivity; mental confusion.

**subclavian vein:** The large vein located beneath the clavicle and joining the internal jugular vein.

**subcutaneous:** Beneath the skin.

**subcutaneous emphysema:** A condition in which trauma to the lung or airway results in the escape of air into body tissues, especially the chest wall, neck, and face; a crackling sensation will be felt on palpation of the skin.

**subdural:** Refers to any lesion in the brain that occurs beneath the dura.

**subdural hematoma:** A collection of blood or clot between the dura mater and the arachnoid usually caused by a laceration or rupture of a meningeal blood vessel.

**sublingual:** Under the tongue.

**substernal:** Beneath the sternum; retrosternal.

**subtrochanteric area:** The area below any trochanter.

**sucking chest wound:** An open pneumothorax.

**suction catheter:** A hollow semirigid tube of various diameters that is used to aspirate material from within the pharynx, trachea, and upper bronchi.

**sudden infant death syndrome (SIDS):** A sudden, unexplained death of an infant within the first six months of life, crib death.

**suffocate:** To impede respiration, to asphyxiate.

**suicide:** The act of deliberately taking one's own life.

**sulfuric acid:** A colorless, nearly odorless, heavy, oily, corrosive liquid containing 96 percent absolute acid; used occasionally as a caustic.

**sunstroke:** A form of heatstroke due to prolonged sun exposure.

**superficial:** Confined to or pertaining to the surface.

**superior:** In anatomy, used to refer to an organ or part that is located above another organ or part.

**superior vena cava:** One of the two largest veins in the body that empty venous blood into the right atrium; receives blood from the upper extremities head and neck.

**supinate:** To turn the forearm so that the palm faces upward.

**supine:** Lying horizontal in a face-upward position.

**suppository:** A drug mixed in a firm base that melts at body temperature, shaped to fit various body orifices, such as the rectum, urethra and vagina.

**suppuration:** Formation or discharge of pus.

**supracondylar fracture:** A fracture of the distal end of the humerus just above the condyles.

**supraventricular arrhythmia:** An arrhythmia arising from any portion of the electrical conduction system that is above the ventricles.

**supraventricular tachycardia:** A rapid regular tachycardia with the ectopic pacemaker originating above the ventricles.

**surgery:** The branch of medicine that deals with trauma and diseases that requires operative intervention.

**suspension:** A dispersion of a finely divided drug in a suitable liquid medium.

**suture:** A type of fibrous joint in which the opposed surfaces are closely united; also, the material used in closing a surgical wound, or repairing a gaping wound.

**swathe:** A cravat tied around the body to decrease movement of a part.

**S wave:** The negative deflection of the ventricular depolarization complex following the R deflection (positive) on EKG.

**sweat gland:** A gland that secretes water and electrolytes through the skin.

**swimmer's ear:** A condition that results from an inflammation of the external ear canal caused by growth of bacteria and fungi in the warm, wet orifice; causes exquisite pain with edema.

**sympathetic nervous system:** A subdivision of the autonomic nervous system that governs the body's reaction to stresses by stimulating the heart, bronchodilation, and other reactions.

**sympatholytic:** A term that describes any agent that blocks any action of the sympathetic nervous system.

**sympathomimetic:** A mimicking of the effects of the impulses conveyed by the sympathetic nervous system; relating to an agent that produces effects similar to those of impulses conveyed by the sympathetic nervous system, hence an alpha or beta sympathomimetic drug.

**symphysis pubis:** The midline articulation of the pubic bones.

**symptom:** A subjective sensation or awareness of disturbance of bodily function.

**syncope:** Fainting; a brief period of unconsciousness.

**syndrome:** A complex of symptoms and signs characteristic of a condition.

**synergism:** The joint action of agents such that their combined effect is greater than the sum of their individual effects.

**synovial fluid:** A clear, viscid fluid that lubricates joints; secreted by the synovial membrane.

**synovium:** The lining membrane of a joint cavity.

**syrup:** A drug suspended in sugar and water to improve its taste.

**systemic:** Refers to anything that affects the body as a whole.

**systemic circulation:** The passage of blood from the left ventricle through the aorta and all of its branches and capillaries and back to the right atrium through the venules, veins, and venae cavae.

**systole:** The period during which the ventricles contract.

**systolic:** Relating to, or occurring during cardiac systole.

**systolic blood pressure:** The highest peak pressure exerted on the arterial walls during ventricular contraction.

## T

**tablet:** A small disc that has been molded or compressed from a powdered drug.

**tachyarrhythmia:** A rapid heart rate, over 120 to 160 per minute.

**tachycardia:** Abnormally rapid heart rate, over 100 beats per minute.

**tachypnea:** Excessively rapid rate of respiration, over 25 per minute in adults.

**talus:** The ankle bone that articulates with the tibia, fibula, calcaneous, and navicular bone.

**tamponade:** A condition resulting from excess fluid accumulation in the pericardium; may result from pericarditis or injuries to the heart, with an accumulation of blood; also the act of plugging with a tampon.

**tarsal:** Pertaining to the tarsus, the ankle.

**tarsal plate:** The thin, elongated plate of dense connective tissue that contributes to the shape of the eyelid.

**TBW:** Abbreviation for total body water.

**telemetry:** The measurement of diagnostic signs by electrical instruments and the transmission of them, especially by radio, to a distant place for recording; used for EKG signals.

**telephone hot line:** A direct, dedicated telephone circuit that connects two or more points for instant communications without dialing.

**temperature:** The degree of heat of a living body; varies in cold-blooded animals with environmental temperature and is constant, within a narrow range, for warm-blooded animals; 98.6 degrees Fahrenheit oral temperature and 99.6 degrees rectal are considered normal for humans.

**temple:** The portion of the head above and anterior to the ears and above the zygomatic arch.

**temporal artery:** The artery located on either side of the face above and in front of the upper portion of the ear; supplies blood to the scalp.

**temporal lobe:** A region of the cerebral hemisphere below and lateral to the frontal and occipital lobes; contains the control center for speech.

**temporomandibular joint (TM joint):** Mandibular joint, the articulation between the head of the mandible and the mandibular fossa and articular tubercle of the temporal bone.

**tendon:** A tough band of dense, fibrous, connective tissue that attaches muscles to bone and other parts.

**tenesmus:** A painful straining of the anal or vesical sphincter to empty the bowel or bladder without evacuation of fecal matter or urine.

**tension pneumothorax:** A situation in which air enters the pleural space through a defective one-way valve in the lung causing progressive increase in intrapleural pressure, with lung collapse and impairment of circulation.

**testes:** The male reproductive glands that produce spermatozoa.

**tetanus:** An infectious disease caused by an exotoxin of a bacteria, *Clostridium tetani,* that is usually introduced through a wound, characterized by extreme body rigidity and spasms, trismus, or opisthotonus, of voluntary body muscles.

**thalamus:** Either one of two grey matter masses situated on either side of the third ventricle near the brain stem; all sensory stimuli except olfactory, are received, synthesized, associated, and relayed to specific cortical areas of the brain.

**thermal:** Pertaining to heat.

**thermal conductivity:** The power to transmit or convey heat.

**thigh:** The portion of the lower extremity between the hip and knee.

**third degree burn:** A full-thickness burn destroying all skin layers and underlying tissue; has a charred or white, leathery appearance; insensitive.

**Thomas splint:** A rigid metal or plastic splint that provides support for and a steady longitudinal pull on the lower extremity.

**thoracic:** Pertaining to the chest.

**thoracic cage:** The rib cage.

**thoracic cavity:** The space within the chest walls between the diaphragm and the base of the neck.

**thoracic spine:** The vertebrae, usually 12 in number, between the cervical spine and the lumbar spine.

**thorax:** The portion of the trunk between the neck and the diaphragm, encased by the ribs; chest.

**thready pulse:** A pulse that is weak or scarcely audible, characteristic of a person in shock.

**three-man lift:** A method by which a number of persons may lift and move a patient smoothly.

**three-point suspension:** The distribution of the weight of a patient while the patient is being moved; trunk, buttocks, and legs are separately supported.

**thrombocyte:** Blood platelet; a cellular element of the blood involved in clotting.

**thrombophlebitis:** A condition in which inflammation of a vein leads to the formation of a clot in the vein.

**thrombosis:** Formation of a blood clot or thrombus.

**thyroid cartilage:** The largest of the laryngeal cartilages, the Adam's apple.

**thyroid gland:** A ductless endocrine gland lying in front of the trachea; produces hormones involved in metabolism regulation.

**tibia:** The larger of the two bones in the leg; the shin bone.

**tic:** An involuntary spasmodic twitching, usually of the face.

**t.i.d.:** Abbreviation for *ter in die;* three times a day.

**tidal volume:** The amount of air inhaled or exhaled during any level of activity; the volume of one breath at rest approximates 500 milliliters.

**tincture:** A diluted alcoholic extract of a drug.

**tinnitus:** A ringing, tinkling, buzzing, or roaring noise in the ears.

**tissue:** An aggregation of similarly specialized cells and their intercellular substance united in the performance of a particular function.

**tolerance:** The state of enduring, or of less susceptability to the effects of a drug or poison after repeated doses.

**tonic-clonic:** Refers to the muscular spasms in which tonic and a clonic phase exist.

**torr:** The Torricelli unit; a measurement of pressure; one torr is the pressure needed to support 1 millimeter of mercury at 0° centigrade.

**torsion:** Twisting.

**total body water:** The total fluid content of the body; equivalent to about 60 percent of body weight in the adult male.

**tourniquet:** A constrictive device used on the extremities to impede venous blood return to the heart or obstruct arterial blood flow to the extremities.

**toxemia:** A condition wherein the blood contains poisonous products manufactured by body cells or micoorganisms.

**toxemia of pregnancy:** A condition sometimes occurring during the second half of pregnancy manifested by symptoms of eclampsia.

**toxin:** Any poison manufactured by plant or animal life.

**toxoid:** A chemically modified toxin that, when injected, stimulates the development of immunity to a specific disease.

**trachea:** The cartilaginous tube extending from the larynx to its division into the primary bronchi; windpipe.

**tracheostomy tube:** A tube inserted into an opening made by a tracheotomy.

**traction:** The act of exerting a pulling force.

**trade name:** The name under which a drug is marketed by a given manufacturer; also referred to as the brand or proprietary name.

**transfusion:** An injection of blood, saline solution, or other liquid into a vein.

**transfusion reaction:** Any adverse reaction, allergic, febrile, or hemolytic produced in a patient due to a blood transfusion.

**transient ischemic episode (TIE):** A temporary condition wherein the blood supply to the brain is interfered with; usually an indication of an impending stroke.

**transmission:** The conveyance of disease from one person to another.

**transverse colon:** The division of the large intestine that crosses the abdomen, located between the ascending colon and the descending colon.

**transverse fracture:** A fracture in which the line of break forms a right angle to the axis of the bone.

**trauma:**

Surgical definition: physical injury.

Psychiatric definition: emotional distress, relating to a specific incident.

**traumatic asphyxia:** A syndrome resulting from a very severe compression injury of the chest; cyanosis of the face and neck, bulging of the eyes, and a flail chest are external results.

**tremor:** An involuntary trembling or quivering of voluntary muscles.

**trench foot:** A foot condition caused by exposure to cold and dampness.

**triage:** A system used for sorting patients to determine the order in which they will receive medical attention.

**triangular bandage:** A piece of cloth cut in the shape of a right-angled triangle; used as a sling, or folded for a cravat bandage.

**tricuspid:** The AV valve between the right atrium and right ventricle.

**trismus:** A spasm of the jaw muscles causing the teeth to be clenched shut; characteristic of tetanus.

**trocar:** A sharply pointed surgical instrument, contained within a hollow cannula, used to puncture a cavity for removal of fluids.

**trochanter:** Either of the two bony prominences near the upper extremity of the femur below the femoral neck; the greater trochanter and the lesser trochanter.

**trunk:** The body, excluding the head and limbs; torso.

**turgor:** The normal state of tension in living cells.

**T wave:** The wave following the QRS on the EKG, representing ventricular repolarization; under certain conditions, or in different leads, it may be positive, biphasic, flat, or inverted.

**tympanic cavity:** The cavity just behind the eardrum, the cavity of the middle ear.

**tympanic membrane:** The eardrum.

## U

**UHF:** Abbreviation for ultra high frequency band; refers to that part of the radio frequency spectrum between 300 and 3,000 megaHertz.

**ulcer:** An open lesion of the skin or mucous membrane.

**ulna:** The larger bone of the forearm, on the side opposite that of the thumb.

**ulnar artery:** A major artery of the forearm; pulse is palpable on the medial wrist at the base of the fifth finger.

**umbilical clamp:** A device, usually made of plastic, used to compress the umbilical cord that allows the cord to be cut without endangering the mother or baby from blood loss; proper cord cutting requires two clamps, one to prevent bleeding from the stump attached to the baby and one attached to the mother.

**umbilical cord:** A flexible structure connecting the fetus to the placenta.

**umbilicus:** The navel.

**unconscious:** Without awareness, the state of being comatose.

**universal access number:** A telephone number that can be called in emergency situations of all kinds and will tie in with the police, fire, and emergency medical services; in most areas the number is 911.

**universal dressing:** A large (9 by 36 inches) dressing of multilayered material that can be used open, folded, or rolled to cover most wounds, to pad splints, or to form a cervical collar.

**uremia:** A toxic condition caused by the inability of the kidneys to remove waste products from the blood.

**ureter:** Either of the tubes that convey urine from the kidneys to the bladder.

**urethra:** The canal that leads urine from the bladder to the urethral orifice.

**urinary bladder:** A musculomembranous bag serving as a storage place for urine until the urine is discharged from the body.

**urinary system:** The organs concerned with the formation and voiding of urine; consists of the kidneys, ureters, bladder, and urethra.

**urine:** The fluid secreted from the blood by the kidneys, stored in the bladder, and discharged through the kidneys.

**urticaria:** Hives.

**uterus:** The muscular organ that holds and nourishes the fetus, opening into the vagina through the cervix; the womb.

**uvula:** The small conical appendix attached to the free edge of the soft palate containing the uvular muscle.

## V

**vagina:** The canal in the female extending from the uterus to the vulva; the birth canal.

**vagus:** The 10th cranial nerve; chief mediator of the parasympathetic system.

**vas deferens:** The spermatic duct of a testicle.

**vascular:** Relating to, or containing blood vessels.

**vasoconstriction:** The narrowing of the diameter of a blood vessel.

**vasoconstrictor:** A drug, nerve, hormone, or other agent that narrows the diameter of blood vessels.

**vasodilator:** A drug, nerve, hormone, or other substance that dilates or widens the diameter of blood vessels.

**vasopressor:** Any agent that raises the blood pressure by causing vasoconstriction.

**vasovagal:** Pertaining to the vagus nerve and blood vessels; a reflex caused by stimulation of the vagus nerve that slows the heart rate.

**vasovagal attack:** A syndrome consisting of hypertension, sweating, anxiety, nausea, and occasionally, syncope.

**VD:** Abbreviation for venereal disease.

**vein:** Any blood vessel that carries blood from the tissues to the heart.

- **femoral vein:** A continuation of the popliteal vein that becomes the external iliac vein, the major vein draining the leg.
- **pulmonary vein:** One of four veins that returns aerated blood from the lungs to the left atrium of the heart.

**velcro:** The proprietary name for a fastener consisting of two strips of nylon tape, one covered with minute hooks, one with minute loops, that lock securely when pressed together and separate easily when pulled apart.

**venae cavae:** The two largest veins of the body returning blood to the right atrium.

- **inferior vena cava:** Principal vein returning blood from the lower portion of the body.
- **superior vena cava:** Principal vein returning blood from the upper portion of the body.

**venereal disease:** A disease generally acquired through sexual intercourse with an infected partner; syphilis, gonorrhea, and chancroid are common ones; Herpes II is becoming epidemic.

**venipuncture:** A surgical puncture of a vein for any purpose.

**venom:** A poison, usually derived from reptiles or insects.

**venous blood:** Unoxygenated blood, containing hemoglobin in the carboxyhemoglobin state.

**ventilation:** Breathing; supplying fresh air to the lungs.

**ventilatory assistance:** A means of providing or improving ventilation during respiratory failure.

**ventral:** Referring to the abdomen; directed toward or situated on the belly surface; opposite of dorsal.

**ventricles:** The thick-walled, muscular chambers in the heart that receive blood from the atrium and force blood into the arteries; also any small cavities; cerebral chambers containing cerebrospinal fluid.

- **left ventricle:** The greater chamber, on the left side of the heart, that propels oxygenated blood through the aorta.
- **right ventricle:** The lesser chamber, on the right side of the heart that propels unoxygenated blood through the pulmonary artery and into the lungs.
- **right and left lateral, third and fourth ventricles:** cerebral ventricles.

**ventricular aneurysm:** A localized dilation or ballooning of the wall of the ventricle, usually the left.

**ventricular fibrillation:** A rapid, tremulous, and ineffectual contraction of the cardiac myofibrils, producing no cardiac output; cardiac arrest.

**ventricular standstill:** Asystole; no muscular contraction of the ventricles.

**ventricular tachycardia:** A serious cardiac arrhythmia with rapid, regular, or slight irregular, ventricular contractions; AV dissociation is present, and often there is no cardiac output.

**Venturi mask:** A brand of breathing unit that has a graduated valve for setting a specific concentration of oxygen delivered through the mask.

**venule:** A very small vein.

**vernix caseosa:** The white, cheesy deposit covering the skin of the newborn.

**vertebra:** Any one of the 33 bones of the spinal column.

- **cervical vertebrae:** The upper seven vertebrae, forming the skeleton of the neck.
- **coccygeal vertebrae:** The three to five lower rudimentary vertebrae of the vertebral column that form the coccyx or tail bone.
- **lumbar vertebrae:** The five vertebrae of the vertebral column between the thoracic and the sacrum.
- **sacral vertebrae:** The five fused vertebrae of the vertebral column that form the sacrum, a part of the pelvic girdle.
- **thoracic vertebrae:** The 12 vertebrae of the vertebral column between the cervical vertebrae and the lumbar vertebrae.

**vertebral:** Pertaining to the vertebrae.

**vertebral arch:** The posterior projection of each vertebra through which the spinal cord passes.

**vertebral body:** The round solid bone forming the front part of the vertebra: articulates with the cartilagenous pads between the vertebrae.

**vertebral spine:** The bony projection dorsal to the arch; the spinous process of the vertebra.

**vertigo:** A dizziness; an hallucination of movement; a sensation as if the external world is spinning; may be right or left, upward to downward.

**vestigial:** Pertaining to a small or imperfectly developed body part or organ that remains from one more fully developed in an earlier stage of the individual, or in the past generations, or in closely related forms.

**VHF:** The very high frequency band; refers to the portion of the radio frequency spectrum between 30 and 150 megaHertz.

**viable:** Living; capable of living.

**vial:** A small glass container.

**virus:** A group of minute structures of living proteins capable of infecting most animal and plant kingdoms, characterized by a lack of independent metabolism and by a complete dependence on live cells to reproduce.

**viscera:** The internal organs of the body.

**visceral pleura:** The serous membrane covering the lungs; produces the pleural fluid.

**vital capacity:** The volume of air that can be forcefully expelled from the lungs following a full inspiration.

**vital signs:** The indication of life through values that reflect mental status, blood pressure, pulse rate, and respiration rate and depth.

**vitreous fluid:** A jellylike, transparent substance filling the inside of the eyeball.

**vocal cords:** Either of two pairs of folds of mucous membrane in the larynx that project into the cavity of the larynx; activated by the passing of air over the folds, causing vibration; source of the voice sound.

**voice box:** The larynx.

**volume expander:** The intravenous fluid that stays in the vascular space, usually a colloid, but can be an isotonic fluid with electrolytes.

**voluntary:** Of, relating to, or acting under obedience to the will.

**voluntary commitment:** The commitment of a patient to a hospital for treatment or observation with the patient's consent.

**voluntary muscle:** Any muscle that functions under the control of the will.

**vomiting:** A forceful, active expulsion of stomach contents through the mouth, as opposed to regurgitation, which is passive.

**vomitus:** The matter ejected from the stomach by vomiting.

**vulnerable period:** The interval during the relative refractory period of the ventricular repolarization corresponding to the downcurve of the ventricular repolarization wave, the T wave, in which ventricular fibrillation is produced by an ectopic impulse or other strong stimulus.

**vulva:** The external parts of the female genitalia.

## W

**walkie-talkie unit:** A compact, battery-operated radio transmitting and receiving set that can be carried to provide two-way communications.

**warning lights:** The flashing lights that serve as a signal on an ambulance or other emergency vehicles.

**warning signal:** An intermittent audible signal of varying tones made by a siren to clear the way for an emergency vehicle; used when going on a call.

**watt:** A unit of electrical energy obtained by multiplying amperes by volts.

**watt-seconds:** A unit of electrical energy expressed as watts per second delivered.

**wet suit:** A close-fitting full-body rubber covering, with zipper fasteners, used by under water divers.

**wheal:** A swelling on the skin, produced by a sting, an injection, external force, or internal reaction.

**wheeze:** A high-pitched, whistling sound characterizing an obstruction or spasm of the lower airways.

**wheezing:** Breathing noisily and with difficulty.

**wind-chill factor:** The relationship of wind velocity and temperature in determining the effect of the factor on a living organism.

**windpipe:** The trachea.

**white blood cell:** Leukocyte; cellular element of the blood that produces antibodies and participates in the inflammatory responses.

**withdrawal:** A symptom produced by abstinence from a drug to which one is addicted, or has been taking.

**womb:** The uterus.

**wrecking bar:** A short, metal crowbar with a slight bend at one end for prying and a claw for pulling nails at the other end; used to remove victims trapped in vehicles.

**wrist:** The joint or the region of the joint between the forearm and the hand.

## X

**xiphoid process:** A sword-shaped cartilaginous process at the lowest portion of the sternum that ossifies in the aged and has no ribs attached to it.

**X-ray:** Electromagnetic radiation; roentgen ray.

**Xylocaine:** Trade name for lidocaine, a local anesthetic; and a depressor of cardiac premature ventricular beats.

## Z

**zygomatic bone:** The cheekbone, the malar bone.

**zygomatic process of the frontal bone:** The massive projection from the supraorbital margin of the frontal bone that articulates with the zygomatic bone.

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